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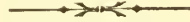
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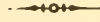
Prof. **S. Watasé**, *Ph. D.*, *Rigakuhakushi*.

280





## CONTENTS.



- Art. 1. K. YENDO :—A monograph of the genus *Alaria*. With 19 plates and 2 textfigures. Publ. May 30th, 1919.
- Art. 2. T. MATSUSHITA :—Untersuchungen über die Wasseraufnahme bei abgeschnittenen Zweigen. Mit 2 Textfiguren. Publ. July 30th, 1919.
- Art. 3. Y. YOSHII :—Oekologische Studien über Vegetation der Ōta Dünen. Mit 2 Tafeln und 8 Textfiguren. Publ. July 30th, 1919.
- Art. 4. Y. EMOTO :—Ueber die relative Wirksamkeit von Kreuz- und Selbstbefruchtung bei einigen Pflanzen. Mit 2 Tafeln und 6 Textfiguren. Publ. March 15th, 1920.
- Art. 5. T. KATŌ :—A contribution to the knowledge of the Cassiterite veins of pneumato-hydatogenetic or hydrothermal origin. A study of the copper-tin veins of the Akénobé district in the Province of Tajima, Japan. With 7 plates and 11 text-figures. Publ. May 10th, 1920.
- Art. 6. S. TSUBOI :—Volcano Ōshima, Idzu. With 6 plates and 42 text-figures. Publ. May 10th, 1920.
- Art. 7. M. TAHARA :—Cytologische Studien an einigen Kompositen. Mit 4 Tafeln und 15 Textfiguren. Publ. March 30th, 1921.
- Art. 8. Y. KUDŌ :—Enumeratio Labiatarum specierum varietatum formarumque in Insulis Kurilensibus et Insula Yezoensi sponte nascentium. Publ. March 30th, 1921.





## A Monograph of the Genus *Alaria*.

By

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*With 19 plates and 2 textfigures.*

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“Bei wenigen Gattungen unter den grosseren Meerespflanzen sind die Ansichten der Autoren über die Zahl der Arten so abweichend, wie bei *Phaeoganon*.”—RUPRECHT.

More than 32 species of *Alaria* have been described by various writers since GREVILLE established the genus in 1830. Not a few of them have been reduced to synonymous positions of the others and only about half of them are now admitted to be more or less valid. But the synonymizations by different writers frequently do not agree with one another so that the true number of valid species is not yet satisfactorily fixed. The complaint made by RUPRECHT seventy years ago may still be repeated by modern algologists.

The ambiguity of the specific limitation of *Alaria* is undoubtedly due to the following facts; first, in most species the stages of development as well as the habit of the plant are not observed by the describer himself, thus different forms of one and the same species due to the ages or conditions of the habitats may often have been mentioned in separate and independent

specific positions; secondly, collectors who know but little of the variability of the forms are inclined to choose smaller specimens in the field as more suitable for herbaria.

The present writer spent a summer on the west coast of Vancouver Island, B. C., and there he actually observed and collected various species of *Alaria* indigenous to the locality. A half-year trip along the Kurile Islands and in Kamtschatka as well as the botanizings on the coast of Hokkaido (Yesso), where he now lives, have also given him many opportunities of studying the subject among living specimens. These two localities are the most important fields for the genus, the majority of the species extant being found there. He also paid special attention to the original and the authentic specimens of the genus during his two years travel in Europe, paying visits to the important herbaria. He now considers himself justified to undertake the enterprise of preparing a monograph of this genus, a genus well defined from the others but very unclear within itself.

The present monograph, however, must not be taken as an exhaustive treatise. The species from the North Atlantic certainly require more extended observation, and some from the north-west coast of North America a careful revision with ample material. It is simply offered as a suggestion with the hope that it may induce others to complete our knowledge on the subject.

In preparing this paper the author is under obligation to Prof. O. NORDSTEDT of Lund for the photographs of J. AGARDH's type specimens, and to Dr. C. SKOTTSBERG of Upsala for an anatomical examination of the type specimen of *Alaria lanceolata* KJELLM. Dr. F. C. E. BÖRGESSEN of Copenhagen has kindly shown me his Faeröese collections and favoured me with various papers written by him on *Alaria*, and Prof. W. A. SETCHELL of Berkeley was



generous enough to spare me two complete specimens of *Alaria valida* SETCH. et KJELLM. I am also indebted to Dr. W. TRANZSCHELL, in charge of the Herbarium of the Academy of Science of Petrograd, Prof. O. JUEL of the Botanical Museum of Upsala, Prof. C. A. M. LINDMAN of the Academy of Science of Stockholm, Prof. Sv. MURBECK of the Botanical Museum of Lund, Prof. N. WILLE of the Botanical Museum of Christiania, and Prof. H. H. DIXON of Trinity College, Dublin, who have given me permission to freely study the original or authentic specimens kept in the herbaria of these institutions. To these gentlemen the author desires to express his sincerest thanks.

### General Morphology.

The post-embryonal frond of *Alaria* is sharply differentiated into three parts, the holdfast, the stipe and the blade or lamina. It is simple for the whole life, neither branches nor stolons being found in the normal forms. It is habitually erect and no dorso-ventrality is indicated in the external appearance and in the internal structure. The stipe is percurrent into the blade running in its median line and elevated equally above both surfaces. The extension of the stipe within the blade is called midrib.

The tissue elements of the frond are practically equal to those found on other Laminariaceous members. The lacunae or mucilage canals which are common in most species of *Laminaria* are entirely wanting in *Alaria*. A peculiar sort of glandular cell, which I<sup>1)</sup> have called mucilage gland, is present in all *Alarias*, at least in early stages of their development.

The so-called cryptostomata are found in some species but

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1) YENDO: On the Mucilage Glands of *Undaria*. 1909.

wanting in others. They are different from those found in Fucaeeae, in structure and in mode of formation.

The characteristic of the genus is the formation of the sporophylls, as the generic name *Alaria* suitably expresses. The sporophylls are small leaflets, each provided with a short but more or less sharply differentiated petiole at its base. They are disposed pinnately or fasciculately on both edges of the terete or compressed stipe.

In minor points, the characters of the frond vary according to the species; or it is better to say, the specific distinctions of *Alaria* lie on the minor differences of the characters. It is therefore a most important matter to ascertain if a character is constant or variable, and consequently, reliable or unreliable for specific distinctions. The observations given below will help to solve the problem, and at the same time explain the standpoint on which the present writer has arranged the species.

### *Stipe.*

The stipe of the embryonal frond of *Alaria* is cylindrical. Its greater part of thickness consists of septated filaments running parallel and compactly arranged. The part is enveloped with a few layers of rectangular cells containing chromoplasts. Later on, it adds to its length by stipo-frondal growth, until the frond reaches the post-embryonal stage. The upper half of the length of the stipe at this stage is more or less compressed with round edges, generally becoming cylindrical downwards. The structure is now more complicated than in the embryonal stage, and does not show much difference in its essential points from that of the other Laminariaceous members. The tissue elements may be briefly

distinguished into three kinds, the epidermal layer, the cortex and the medulla.

In the cylindrical part of the stipe, the epidermal layer and the cortex form concentric rings when observed in cross sections (Plate XVIII, fig. 12). In the center of the circular section the medulla of a compressed elliptical shape is found. Interposed between the medulla and the cortex there is a zone of distinct structure, sheathing, as it were, the former. It is clearly distinguished from the two parts by having large cells of irregular arrangement and fibrous cells compactly interposed among them. Within this is the elliptical medulla with its major axis nearly equal to the diameter of the said area. I will call the area "perimedullary tissue" for convenience' sake. This tissue is the main source of the medullary hyphae, agreeing with the similar tissue in the stipes of *Laminaria*. The cells are remarkably thick-walled. When stained in a solution of aqueous anilin blue the cell-wall gives a vivid differentiation of blue colour in sharp contrast to that of the other parts. Similar result has been obtained by WILLE<sup>1)</sup> by treating the tissue with chloriodide of zinc (Plate XVIII, fig. 16).

The large, thick-walled cells in the perimedullary tissue must not be confused with the similar ones scattered in the medulla. In the cross sections they appear very much alike. Longitudinal sections, however, reveal the fact that the former are cylindrical cells forming continuous filaments of uniform diameter, and that the latter are the swollen parts of the trumpet hyphae. Some of the trumpet hyphae become thick-walled, as has been already observed by WILLE<sup>2)</sup>, and may assume a similar appearance, in

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1) WILLE: Beiträge z. physiolog. Anatom. der Laminariaceen, p. 26, fig. 11.

2) WILLE: l. c., fig. 37.



the cross sections, to the perimedullary cells. Some other trumpet hyphae, however, remain thin-walled and may contain a hyaline, highly refracting, cartilaginous substance on both sides of the sieve plates. This substance turns yellowish in the dried specimens, and stains deep blue by aqueous anilin blue, proving in every point the callus formation observed by SYKES<sup>1</sup>) (Plate XVIII, fig. 15, 16, 18).

The fibrous cells interposed between the large cylindrical cells of the perimedullary tissue disappear by degrees towards the periphery of the stipe, and the cylindrical cells become at the same time disposed in a more or less regular, radial direction. Hence, in the cross sections, this part appears under the microscope like a parenchymatic tissue.

From the outer part of the perimedullary tissue the cortex begins quite abruptly. It occupies a greater part of the thickness of the stipe and assumes the part of the xylem of a tree. The term cortex does not at all express the true character of the tissue but has been invariably applied to this part by former writers. It is marked by having cells of much smaller diameter than the tissue lying just inside, and by having very few fibrous cells. The inner part of the cortex has the cells generally irregularly disposed and some fibrous cells may still be found interposed between them. In the outer part, the cells become gradually regularly radiate and narrow-lumened until it passes quickly into the epidermal layer. In the longitudinal sections, the inner cortex differs from the outer by having the cells longitudinally elongated but much undulating, while in the latter they are stretched transversely (Plate XVIII, fig. 12).

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1) SYKES: Anatomy and Histology of *Macrocystis pyrifera* and *Laminaria saccharina*, p. 320. Cfr. Pl. XIX, fig. 19, 21, &c.

The cylindrical cells in the perimedullary tissue and the cells of the cortex have numerous pits in their cell-walls. They are septated by thin middle-lamellae so as to hinder the free passage of cell-contents. Their abundant presence in the cell-walls gives a very irregular appearance to the forms of the cell-lumens, especially when the latter are as narrow as in the cortical part. A similar structure has been excellently illustrated by WILLE<sup>1)</sup> for the cortical part ("mechanische Gewebe") of *Alaria esculenta*, GREV., and by McMILLAN<sup>2)</sup> for that of the *Pterygophora* stipe.

The cortex and the epidermal layer appear as continuous, more or less regular, radiating lines. The latter may be distinguished from the former by having cells of thinner membrane and greater diameter and by the chromoplasts. The limitation of the two parts is not sharp in the first-year fronds, but is sudden and well-marked, together with an annual ring, in the second-year fronds (Plate XVIII, fig. 12).

WILLE<sup>3)</sup> also distinguishes four concentric zones in the structure of the stipe of *Alaria esculenta* of "wenigstens vier Jahre alten Exemplaren." His "Zone 1" corresponds to the epidermal layer, "Zone 2" to the cortex, "Zone 3" to the perimedullary tissue, and "Zone 4" to the medulla in the above description.

The mucilage lacunae, very common among *Laminaria*, are entirely wanting in the stipe of *Alaria*. Instead of them there are, at least in an embryonal stage of the frond, the mucilage glands. They are found in the epidermal layer immersed at the depth of a few cells, dispersed without any definite order along the periphery. As the meristematic layer of the cortex lies in a

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1) WILLE: Beiträge z. physiolog. Anatom. der Laminariaceen, fig. 14.

2) McMILLAN: Observations on *Pterygophora*, Pl. LXII, fig. 6-7.

3) WILLE: Beiträge z. physiolog. Anatom. der Laminariaceen, p. 17.

much deeper places than the site of the glands, they are never in double rings in the stipes of the second-year fronds. The glands are not remarkably larger than the cells of the epidermal layer and hence less conspicuous when compared with the lacunae of *Laminaria*. When the sections are stained in fuchsin and anilin blue (aqueous), however, the glands get blue-coloured, while the contents of the other cells become bright crimson red.

In the complanated part of the stipe, the arrangement of the tissue elements is greatly modified in comparison to the cylindrical part, so as to be adapted for the shape and for the future issue of sporophylls (Plate XVIII, fig. 13). The medulla is much complanated and stretched transversely, extending almost the whole width. The perimedullary tissue is here found as a very narrow area bordering around the medulla. The greater part of the thickness of the stipe is occupied by the cortex. The cells of the inner cortex are uniform in diameter and much more regular in shape than in the cylindrical part. In either marginal part, only a limited thickness of the cortex is allowed to occupy the narrow space between the epidermal layer and the perimedullary tissue. The epidermal layer shows no practical difference in both parts.

A point which requires attention in the structure of the complanated part of the stipe is that the boundary between the cortical portion and the perimedullary tissue, *i. e.* the innermost part of the inner cortex, is sharply demarcated by a layer composed of compactly arranged, narrow-lumened, cylindrical cells. These cells may be taken as a modification of the cortical cells, as they gently pass into the form of the latter. This layer is not noticeable in the cylindrical part but is much more markedly developed in the midrib (Plate XVIII, fig. 15). In this respect, the complanated

part of the stipe shows an intermediate character between the two parts just answering to its position in a frond.

In the two-year old stipe, the arrangement of tissues above spoken of remains unaltered in both the complanated and the cylindrical part of the stipe. But a new cortical ring appears between the epidermal layer and the primary cortex. In the cylindrical part it forms a continuous sheath of uniform thickness. In the complanated part, it is markedly thickened on both margins, and wing-like ridges on the edges of the stipe are accordingly formed. The midrib has no second-year cortex (Plate XVIII, fig. 12-14).

I have used above the expressions "annual ring" and "second-year cortex" for the stipe of *Alaria* plants. WILLE gives an account of the structure of *Alaria esculenta* in detail in his Beiträge zur physiologischen Anatomie der Laminariaceen, p. 17, and says: "wiefern wirklich auch das Vorkommen einer solchen Jahresringbildung bei noch älteren Individuen von *Alaria esculenta* (L.) GREV. möglich ist, kann selbstverständlich nach Untersuchung dieses verhältnismässig jungen Materiales weder verneint noch bejaht werden." His material is said, according to his estimation, to have contained four-year old plants. I agree with him that what ARESCHOUG<sup>1</sup> remarked of *Alaria* "truncus ima basi 3-4 annulis ornatus" should not be taken as of the annual rings in a similar signification as for the phanerogams. ARESCHOUG's description should be taken as simply 3-4 concentric zones of tissues seen in the cross sections of the stipe. I have no doubt, however, that the growth in thickness of the stipe of a two-year old *Alaria* plant is by virtue of the secondary thickening of the pre-existing cortex. The demarca-

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1) ARESCHOUG: Observations Phycologiae, V, p. 16.

tion between the old and new cortex, as alluded to above, is sharp and clear, especially when we treat the sections in a staining material. It may be well called "annual ring" in agreement with phanerogam taxonomists.

The length of the stipes varies considerably according to the species and to the condition of place where the plant grows. *Alaria Pylaii* GREV. is characterized by having the stipe several inches or even more than a foot in length. But in most species of *Alaria* it hardly exceeds a few inches before the plant begins to bear sporophylls. A typical stipe of *Alaria* is terete or cylindrical at the lowermost part just above the holdfast. It becomes gently compressed upwards, more or less broadening at the same time until it is suddenly narrowed near the transition region. The first sporophyll appears as a ligulate proliferation at a point generally above the middle point of the post-embryonal stipe. New sporophylls are given rise successively above the older ones while the stipe gains in length at the transition point by stipo-frondal growth. The lower naked part of the stipe later grows in thickness, but keeps the length of the post-embryonal stage. In a gigantic form such as *Alaria fistulosa*, several dozens of sporophylls may be already formed before the lowermost one has become soriferous. But in others, there are not so many sporophylls at one time. The oldest ones usually drop off before the plant attains its most vigorous state of growth. When the sporophylls fall away, the greater part of the length of the petioles accompany them, leaving but a small part as verruculose protuberances on the margins of the stipe. As the frond grows further and the stipe increases in length in the transition region, new sporophylls are added successively above, and the lower part of the stipe becomes cylindrical, obliterating the verruculose protuberances.



*Alaria ochotensis* is the only example in which the petioles of the dropped sporophylls remain permanently attached on the stipe (Plate III, fig. 1).

In an advanced stage of development, the scars of the dropped sporophylls are often hardly perceptible, except in *A. ochotensis*. Hence the lower part of the stipe becomes much longer than in the younger stage. Some writers distinguish the sporophyll-bearing portion of the stipe from the naked, by calling them rachis and stipe respectively. To a certain extent this distinction appears to hold good in external appearance and in internal structure. But the limitation of the two parts is gradual and unfixed as may be granted from the above elucidation. In the present paper, therefore, both parts are included under the single term stipe.

The habitat of the plant undoubtedly influences the length of the stipe of *Alaria*. In one and the same species, those individuals found in water of less salinity, in a shaded place or in a deeper water have longer and slenderer stipes than those in other conditions. It is to be understood that the length of the stipe, in any sense, can not be taken as an important character for specific distinctions.

### ***Blade.***

In all species of *Alaria* the blade is simple for the whole life. But the older parts of fully grown blades are pinnately split, in the mode characteristic to the genus. The general outline of the blade is linear with attenuate, cuneate or roundish base, and a midrib running longitudinally on the median line percurrent from the stipe. The apex of the blade begins to wear away at an early embryonal stage and the process continues as the blade elongates by stipo-frondal growth.

The length of the blade varies greatly according to the species. Of *A. fistulosa*, KJELLMAN<sup>1)</sup> reports to have measured its largest specimen in the Bering Sea at about 60 feet. MIYABE<sup>2)</sup> states that it is said to be as long as 200–250 feet. I have measured a specimen about 85 feet long which was cast ashore on Shimushu Island, the northern extremity of the Kuriles. The breadth of the blade of this species attains nearly 3 feet. This species no doubt has the largest simple blade in the vegetable kingdom. In a specimen of *A. tenuata* I found the blade to be 3.5–5.0 cm. in breadth and 3.70 meters in length—recalling a stripe of bandage. In other species, however, the length of the blade, absolute or in proportion to the breadth, is much less than those two examples. Generally, the maximum breadth of a blade is at a point about  $1/5$ – $1/3$  of the whole length from the base.

In most species of *Alaria*, if not in all, the blade splits pinnately, like a *Musa* leaf, in the older parts. In certain species there seems more or less differentiation of the tissue adapted for this process. The cortical layers as well as the hyphal cells of the medullary layer of the blade run at large patently from the midrib, and the epidermal layer is composed of angulate cells disposed in less fixed direction. In *A. fistulosa*, *A. macropteria*, etc., the fine parallel wrinkles which give a marked feature to the older portions of the blade, are principally due to the peculiar arrangement of the medullary tissue (Plate II, fig. 2). The mechanical force of the waves acting upon the blade splits it in the resultant direction of the hyphal cells.

The segments of the split blade are rectangular, if the splitting is in the direction at right angles to the midrib, and more or

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1) KJELLMAN: Om Beringhavets Algflora, p. 41.

2) MIYABE: Laminaria Industry of Hokkaido, p. 52.

less rhombic, if in an oblique direction. In certain species, however, those in the upper portions of the blade are curved or even reflex, not unfrequently with subulate upper corner. *A. augusta* shows a remarkable example of this (Plate XV, fig. 2). Very likely this indicates a partial growth in the segments still going on after they have been split.

Not only in species of *Alaria*, but in most of the Laminariaceous genera, the growth of the frond at an early stage of development is displayed mainly lengthwise. The full length of the blade is attained while the frond is yet immature. How speedy this growth is may be well imagined from the fact that the enormous length of the blades alluded to above is completed within 3-4 months. In this stage, the blade is much narrower with the transition region more tapering towards the stem than in the adult form. When the growth in length has more or less retarded, the increase of breadth takes place as a secondary growth. The process is most remarkable in the transition region, hence the form of the blade undergoes a remarkable change. A blade which is to have a roundish or cordate base in a matured plant may have a cuneate or even attenuating one while in its vigorous growth in length.<sup>1)</sup>

Another factor which influences the shape of the blade of a Laminariaceous species is the movement of water in which it grows. In a quiet bay the blade becomes much thinner and broader than on an open coast; and on an open coast, a plant growing in a deeper region has broader blades than one near the tidal marks.

The general statement given above holds good for most species

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1) YENDO: Three New Marine Algae from Japan, p. 160.

„ Development of *Costaria*, *Unclaria*, and *Laminaria*, p. 702.

of *Alaria*. Describers of *Alaria* must be cautioned not to put much stress upon the shape of the blade as a specific character unless a number of matured forms from different habitats have been considered.

In *Alaria*, the wearing away of the upper portion of the blade is comparatively quicker than in other genera. In the matured form with fully developed sporophylls the upper half of the blade is in most cases already decayed. The general outline or the entire length of a blade is therefore frequently difficult to ascertain. The statement on these points can be conventional and must never be regarded as of equal importance and exactness with that of other characters.

Certain species are defined as having thin and soft blades, as if the character were peculiar to the species. Not a few sterile specimens of *Alaria* which I have seen in various herbaria kept under *A. Pylaii* GREV. showed no important systematic character to justify the determination, except that the blades were thin and soft. There is no need to mention that the blade of a young individual of a Laminariaceous species has a thinner and softer substance. The inhabitants in quiet bays, especially where the salinity of the water is below the normal, may have the blade thin and soft during its whole life.

The term membranaceous, papyraceous, coriaceous, etc., are generally applied by systematists in qualifying the context of foliose fronds of various algae. In the specific distinction of *Alaria* these terms are also applied. Even in the adult forms and those of similar habitat, the apparent context of the blade in a herbarium specimen varies greatly according to the mode of preparation. The specimens mounted directly from a living specimen, whether soaked in freshwater or not, generally remain much thicker than those which have been first dried in the air and afterwards soaked in

freshwater and then mounted. *A. fistulosa*, the largest form of the genus, has the blade enormously thick and practically leather-like while in its fresh state. But when mounted for a herbarium specimen in the latter method related above, the blade turns into a thin and brittle papyraceous substance.

When a dried specimen is sectioned and dipped in water it swells up much more than to its former natural thickness. In such specimens it is rather difficult to discern the true anatomical character of the frond. A comparison of the details of construction of the blades of different species is therefore beyond my present enterprise. In the present paper the distinctive terms are still used, but very cautiously.

### *Midrib.*

The term midrib as applied to the Laminariaceous frond is sometimes found to be used ambiguously. The thickened area which runs longitudinally in the middle of the blade of *Laminaria*, *Pterygophora* and the like, and the sharply defined longitudinal elevation on the blade of *Alaria*, have been equally called midrib by McMILLAN.<sup>1)</sup> SETCHELL<sup>2)</sup> previously seems to have been reluctant to adopt this usage since he chose to call the former "a sort of indefinite midrib" and for a similar thickened portion of the blade of *Pleurophyucus*, "midrib" in quotation marks. In my former papers<sup>3)</sup> the area is termed "meridional region."

Quite recently OKAMURA<sup>4)</sup> published a paper treating of the relationship of *Laminaria Peterseniana* KJELLM., *Hirrome undarioides*

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1) McMILLAN: Observations on *Pterygophora*, p. 737. 1902.

2) SETCHELL: Distribution of Laminariaceae, p. 347. 1893; and Notes on Algae. I. p. 123. 1901.

3) YENDO: Development of *Costaria*, *Undaria* and *Laminaria*, p. 711.

4) OKAMURA: *Undaria* and its Species, p. 269.



YENDO and *Undaria pinnatifida* SUR. The first species has no true midrib but a thick meridional area, on which the sori limitedly develop. OKAMURA termed the area "fascia." The other two species have the true midrib which remains absolutely sterile. In spite of remarkable morphological differences, he proposes to bring them all under the single genus *Undaria*, extending its conception. I hold, however, the view that the midrib in the blades of *Alaria*, *Undaria* and *Hirrome* should be taken as a special organ of distinct significance. The gradations of the soral localizations of the three species as illustrated by OKAMURA may well indicate that they are genetically related to one another, directly or indirectly, but can not have more significance than that, in the modern principle of systematic survey.

The true midrib has a well-marked structural difference from the laminal part. The most striking point is the longitudinal course of the cortical and the hyphal cells in the former, while they run at large decussately or patently from the midrib in the latter. In the meridional and the extra-meridional area of the blade of *Laminaria*, they run equally in the longitudinal direction; also in *Laminaria Peterseniana* and *Pterygophora californica*. Hence it is quite natural that the fresh blade of *Laminaria* tear longitudinally, but curiously the dried ones tear transversely.

In *Agarum Gmelini* the thickened meridional area approaches in structure and in appearance to the true midrib; and more so in *Agarum Turneri*. In this respect, the midrib of *Agarum* may be taken as a link showing intermediate characters between the true midrib and the meridional area.

The typical midrib of *Alaria* is complanated with rounded edges, elevated equally above both surfaces of the blade. The cross sections, therefore, show an elongated elliptical shape with a

semiblade extending horizontally from each margin.

In young fronds, the midrib slants towards the margins, giving a biconvex shape to the cross sections. Some species keep this character unchanged. But in others, the marginal parts gradually thicken as the frond grows up, eventually to form perpendicular edges. The cross sections are now compressed rectangular.

The thickness of the midrib varies according to the species as well as to the age of the frond, often measuring 12 times as thick as the laminal part. The breadth of the midrib in a blade is nearly uniform from the base to the apex. In young post-embryonal fronds, however, the upper part is naturally narrower than the lower.

The tissue elements and their arrangement in the midrib are essentially equal to those of the complanated part of the stipe, except that there are no mucilage glands in the former. The greater part of the thickness is occupied by the cortical portion. In other words, the elevation of the midrib above the blade is mainly due to the remarkable development of the cortical tissue (Plate XVIII, fig. 14).

The structure of the cortical portion is practically the same in the midrib and in the stipe. In the former, however, the cells of the inner cortical portion are more thin-walled and greater in diameter, uniformly cylindrical, and run closely parallel in longitudinal direction. In the cross sections, these cells show angulate polygonal shape, with narrow or scanty intercellular spaces, and are disposed in compact, anticlinal rows (Plate XVIII, fig. 16). In the blade, the cortical cells are much more loosely arranged and take a decussate or patent course from the midrib as alluded to above.

The medullary layer in the sense as taken in the present monograph is a very thin layer extending nearly the whole width of the midrib. It is surrounded by the perimedullary tissue in the manner related to for the complanated part of the stipe. The term medulla used by former writers for the central tissue of the Laminariaceous midrib comprises the medulla and the perimedullary tissue together. In most species of *Alaria*, the layer is considerably thickened at a point near each margin of the midrib. For convenience' sake, I will call the point "marginal swelling of the medulla" (Plate XVIII, fig. 14, *h*).

The medullary layer in the midrib is built up of the same elements as that in the stipe and the blade, *i.e.*, trumpet hyphae and fibrous cells. The proportions of the components differ somewhat according to the species, but in most cases there are more trumpet hyphae in the midrib than in the blade. The marginal swellings of the medulla show great variation in form and tissue elements characterizing the species to a certain degree. In some species, in the cross sections of the midrib, they are narrow lanceolate in shape, in others, ovate or nearly roundish; in some species, they are composed of more trumpet hyphae and less fibrous cells; in others, a narrow middle portion is composed of fibrous cells only, a mixture of both surrounding it. Cfr. Plate XVIII, fig. 15, 16.

The part just overlying the perimedullary tissue, *i.e.*, the innermost part of the cortical tissue, is composed of cells which resemble the cortical cells in shape but are much smaller. The differentiation of this layer is indicated in the complanated part of the stipe, as has been alluded to above. The thickness of the medullary sheath, as it may be provisionally called, varies in different parts of the medulla, being, in most species, much thinner

around the marginal swellings. The relative thickness of the medulla, perimedullary tissue, and the medullary sheath, and the compactness or looseness of the cells of these tissues, show great variation according to the species.

From the outer limits of the marginal swellings of the medulla, the medullary tissue runs directly to the blade. Hence, the blade-medullae in both semiblades are practically continuous, with the midrib-medulla interposed at the middle. The cortical tissue of the midrib, however, is sharply divided from that of the blade by a special tissue intervening between them. This tissue is composed of thick-walled, small cells, and compactly fills up the spaces which lie between the outer parts of the marginal swellings of the medulla and the epidermal layers at the outer margins of the midrib. The term "spanning cortex" is applied to this tissue in the descriptive part of the species (Plate XVIII, fig. 14, *k*).

WILLE<sup>1)</sup> gives in detail structural accounts of the midrib of *Alaria esculenta* GREY. His description agrees in essential points with the observations stated above. What he calls "Assimilations-System" corresponds to the epidermis in the present Monograph, "das mechanische System" to the cortex, and the "Leitungs-System" to the medulla and the perimedullary tissue taken together.

The midrib of *A. fistulosa*<sup>2)</sup> displays various peculiarities in its external appearance as well as in the internal structure. Its axial part becomes intermittently hollow inside, and is elevated on both surfaces so as to answer the cavities or bores. The outer edges of the midrib are not rounded or slant but sharply angulated, already at the early stage of development of the frond, and get

1) WILLE: Beiträge zur physiol. Anatomie der Laminariaceen, p. 24.

2) For a fuller account on the midrib of *Alaria fistulosa*, see, KIBBE: Some Points in the Structure of *Alaria fistulosa*. (Puget Sound Mar. Station Publications, Vol. I, No. 8. 1915).

markedly prominent as the bores are completed. Plate I, fig. 4 will speak better than description.

The boring is practically a lysigenetic result, taking place in the axial region of the medulla at the post-embryonal stage of the frond. Disorganized hyphal cells and the residual trumpet cells, often filled with callus, are found on the inner surface of the bores. The medullary tissue is poorly developed near along the bores but markedly thickened at the marginal swellings. The perimedullary tissue is absent along the bores but well developed in the complanated regions of the midrib, and terminates at its marginal elevations. The spanning cortex is also to be seen at each marginal elevation of the midrib (Plate I, fig. 4).

The cortical portion of the midrib of *A. fistulosa* is composed of irregularly arranged parenchymatic cells. The greater part of the thickness of the bore-wall is occupied by this tissue.

The shape of the cross section of the midrib has often been used as a distinguishing character of *Alaria* species. Repeated observations on various species have taught me the danger of adopting such a view. As stated before, the midrib is much complanated with sloping edges while the blade is yet young. When the secondary growth in breadth begins to take place in the blade, its midrib gains the characters of a matured plant. By referring to the figures in the accompanying plates (Plate XI, XIII, fig. 2-3) the reader will readily understand to what degree the cross sections of the midrib of a species may vary. Certain species have of course a peculiarity in their midribs and this peculiarity may be already perceived even in an early stage of development. *A. fistulosa* can not be mistaken for others by its intermittently hollow midrib. Yet, the distinguishing of species of *Alaria* by mere cross sections of the midrib,—at least to put a great im-



portance on them,—especially in immature specimens, is not advisable. Upon this ground, the present writer mentions *A. linearis* STRÖMF. and *A. flagellaris* STRÖMF. under the “species doubtful,” referring to the authors who held a similar view to STRÖMFELT.

KJELLMAN<sup>1)</sup> seems to have put too much stress on the breadth of the midrib in describing his species from the Bering Islands. Some systematist went too far in following his view tending to value the breadth of the midrib above other characters, eventually resulting in an awkward identification.

When dried, the breadth of the midrib of *Alaria* decreases to a considerable degree. In some specimens I have observed it to lose 30–50% of breadth on drying. The midrib of a dried specimen of *A. valida* SETCH. et KJELLM. was 5 mm. in breadth. In putting a part of the midrib in freshwater I found it to expand to a breadth of 15 mm. I have not observed the species in a living state and hence am not able to state the actual contraction of the midrib by drying. Referring to the measurement given by SETCHELL (22 mm.), I think the breadth regained by soaking in freshwater not to be very far from the measurement in its fresh state. These examples show that the breadth of the midrib of *Alaria* when measured in a dried specimen will often differ greatly from that of the fresh specimen.

JÖNSSON<sup>2)</sup> illustrates an interesting example in the difference of measurements of various parts of the frond of *A. grandifolia* J. AG. by soaking and drying. He remarks:—“These measurements of plants in wet and dry state prove that their total length is reduced 15% by the drying process, the length of the lamina 11.5%, the breadth of the lamina in one case (A) 16.6%, in

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1) KJELLMAN: Om Beringhafvets Algflora.

2) JÖNSSON: Marine Algae of East Greenland, p. 22, footnote.

another case (B) 21%, and the length of the stipes 22.5%. A single measuring like this does not allow of any general conclusion as to the normal reduction by drying of the several species of *Alaria*, but as generally the descriptions do not state whether the measures refer to living, soaked, or dried material, it nevertheless shows, that it is not justifiable to let too small a difference of size (breadth or length) have worth as a character of species, variety, or even of form." Jönsson did not give anything about the midrib. His statement here quoted may be said to apply to the midrib, and in this case probably is of more importance.

### *Sporophyll.*

The sporophylls of *Alaria* are small leaflets distichously arranged on both edges of the stipe. They are always perpendicular, *i.e.*, paratropic. They vary in shape according to the species, from narrow linear to moderately broad ovate, ending with a cylindrical petiole at the base. In some species the petiole is sharply defined from the roundish or cordate base of the sporophyll and in others gently passing into the cuneate base. Many species have the base of the sporophyll asymmetrical or hemiphyllous, but towards which direction the base grows broader is not fixed even in an individual. The soft but tenaceous, slender petiole is not stiff enough as to fix the direction. The number of sporophylls on a stipe is also variable. In some species they are comparatively few, in others numerous. *A. fistulosa* has the largest number and may have several dozens on each side of the stipe (Plate I, fig. 1).

In the species with a very short stipe, the first sporophyll appears at a point near the holdfast, but in those with a moderately long one, at about the middle of the length. The few early-

formed sporophylls are distantly disposed, but the later-formed, normal-sized ones are more approximate. They are alternate in some species and nearly opposite in others. But such arrangement can be discriminated only in the early-formed sporophylls, as the middle and upper ones are generally quite close together. In all species, new sporophylls appear successively above the older ones as the stipe increases in its length at the transition point. The lower older ones drop off one after the other leaving verrucose scars on the edges of the stipe. In some species, however, the growth in length of the stipe ceases before long, and the sporophylls are condensed to a limited point. A noteworthy example of such is seen in *A. angusta*. In it the sporophylls, except a few early-formed ones, grow fasciculately from a point in an upper part of the stipe, the point being much broader and more compressed than the naked portion (Plate XV, fig. 1).

The sori cover the greater parts of both surfaces of a sporophyll, leaving always a narrow border along the margin and frequently a sterile membranous portion on the upper end.

After having examined a considerable number of specimens of *Alaria*, the present writer has come to the conclusion that one is not justified in determining the species of *Alaria*, except in a few cases, unless a specimen with fully matured sporophylls is before him. The other parts of the frond serve of course to help the determination but should never be used alone. Sterile specimens of *Alaria* from the North Pacific where various species occur simultaneously at the same place, are seldom determinable with certainty.

The value of sporophylls as a specific distinction of *Alaria* lies in two points: *a*) their general shape and texture; *b*) their disposition on the stipe.

a) Shape and texture of sporophyll. In describing the shape of sporophylls of *Alaria*, the term linear, ovate, obovate, etc., and their combinations have been applied; and for the texture, coriaceous, cartilaginous, membranaceous, etc. Generally speaking, the sporophylls of *Alaria* are narrow and thick when the plant grows on a surfing rock or near the low water mark, and broad and thin, when in a quiet cove or in a deeper place. McMILLAN<sup>1)</sup> observes on Vancouver Island that *Alaria nana* has much broader and more sporophylls when it is found at a higher formation on surfing reef. He attributes the abnormality of the form to its adaptation to the cumaphytic habitat. The fluctuation of the morphological characters due to the difference of the habitats, however, is quite trifling in comparison to that due to the stages of their development.

A few of the earliest-formed sporophylls are in most species different in shape and size from those formed at vigorous growth of the frond. They are generally smaller and shorter, and distantly disposed. Many examples may be given, where specimens of various species at such a stage have been erroneously identified with *Alaria Pylaii* GREV.

After a close study of the development of sporophylls in various species I can safely divide *Alaria* into two sections, Holoria and Metasoria, on account of the changes of the appearance and texture of the sporophylls during their growth:—

I. HOLOSORIA. Sporophylls of the species under this section are in most cases thick and coriaceous from the beginning. Their growth in length and breadth stops at a certain limit and then the entire surfaces, except the narrow borders, become soriferous. The sori begin to appear as a continuous patch on the lower half

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1) McMILLAN: Cumaphytism of *Alaria*, p. 147.

of length of the sporophyll extending gradually towards both ends. The apex of the matured sporophyll is round and entire, and in certain species a sterile portion may be left there. The general statement given by SETCHELL<sup>1)</sup> about the development of the sporophylls of *Alaria* holds good for the plants of this section (Plate I, fig. 1).

II. METASORIA. Sporophylls of the species under this section are thin and membranaceous or papyraceous at the beginning. If the hair-tufts or the mucilage glands are present in the blade, they are also well developed in the sporophylls. They are therefore functioning as a vegetative organ. Later on, they increase in length by basipetal growth at a limited region near the petiole. The newly formed portion is of much thicker texture, and in some species is remarkably broader or narrower than the thin upper part. The latter part wears away by degrees from the apex. The thicker part becomes soriferous. The matured sporophylls have generally certain portions of the thin and sterile foliole still remaining at their upper end, but not unfrequently are entirely free from it (Plate IX, fig. 1-3).

When there is ample material showing various stages of development of frond, the distinction above given is easily recognizable. If, however, we have only very young or fully matured sporophylls in a specimen the matter is not so apparent. Very frequently we meet with the fully matured sporophylls of the Metasoria entirely free from the non-soriferous portions. In such case one is apt to take the plant to belong to the Holororia. With but a few exceptions, the matured sporophylls of the Holororia have broad and rounded apices with entire margins, while

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1) SETCHELL: On the Classification and Geographical Distribution of the Laminariaceae, p 347.



those of the Metasoria, more or less narrowed apices with rough margins.

Although the apical part of the sporophyll is variable in appearance, as explained above, the basal part has a constant character more or less specifically distinct. In some species the base tapers gently into the petiole, and in others is cordate or round with sharply defined petiole; in some species it is asymmetrical in a peculiar manner and in others always symmetrical. By these characters of the sporophyll, together with its general outline, we can often readily tell the species even in a specimen with the whole part of the blade withered away.

b) Disposition of sporophylls on the stipe. The various modes of disposition of sporophylls are expressed by the terms pinnate, distantly pinnate, fasciculate, etc., which shall be used and regarded with utmost care. Early European botanists to whom only *A. esculenta* has been the familiar species, were rather careless in describing the character.

ROSENVENGE<sup>1)</sup> and JÖNSSON<sup>2)</sup> are of the opinion that the position of the sporophylls is not of any systematic importance. As has been already stated, the early-formed sporophylls are disposed on the stipe at much wider intervals than the later-formed ones. It is therefore apparently right to agree with these two botanists, when we compare different-aged plants of one and the same species. But when fully matured plants of the different *true* species have been laid before us we can make out in each a more or less constant character in the disposition of the sporophylls.

*Alaria esculenta* GREV., the type of the genus, has the sporophylls arranged regularly pinnate, with nearly constant intervals

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1) ROSENVENGE: Grönlands Havalger, p. 839.

2) JÖNSSON: Mar. Alg. East Greenland, p. 23.

between the successive two; so also in *A. prælonga* KJELLM. and *A. crassifolia* KJELLM. In *A. angusta* KJELLM., the sporophylls are condensed to a short, limited length of the stipe, and the insertions of the petioles are fused together to form a narrow wing-like portion on either margin of the stipe. *A. nana* SCHR. is unrivalled among the genus in having the sporophylls ascending. *A. Pylaii* GREV. is well known by having them at wide intervals on a long stipe. All other species may belong to one of these examples, or may have a certain peculiarity in the disposition of the sporophylls.

### *Holdfast.*

In the early embryonal stage of the frond, the holdfast of *Alaria* is a simple scutellate body firmly attached to the substratum with its under surface. It is better to call it hapter at such stage. From all sides of the stipe just above the hapter arise rhizines in an irregular whorl, furcating repeatedly towards the periphery, each ramulet terminating in a small hapter. New rhizines come out from the stipe above the older whorl as the frond develops. The thickness and complicaacy of the rhizines increase in the new ones. The primary hapter and the early-formed rhizines decay by degrees. In these respects the mode of formation of the holdfast of *Alaria* agrees with what has been hitherto observed on various other genera of Laminariaceæ.

The rhizines of the holdfast are generally cylindrical in every segment. In *A. tæniata* KJELLM. and *A. angusta* KJELLM., however, the principal segments, *i. e.*, the segments directly connected with the stipe, are stout and compressed and rhizines are very few in number and short in length (Plate XV, fig. 1). The holdfast of *A. fistulosa* is built up of innumerable, long, filiform rhizines,

compactly interwoven together. Its general outline becomes tall conical, measuring, in a full-grown specimen, 30–40 cm. in height and 15–20 cm. in diameter at the base (Plate I, fig. 1). Excepting these few cases, the holdfast of *Alaria* may be said to be as in the typical form of Laminariaceæ.

The tissue elements of the rhizines are quite simple in comparison with the stipe. Their inner part is constructed of filiform, less branching, narrow tubes, septated at various lengths. These tubes run longitudinally but undulating. In the axial part they are somewhat loosely disposed, without any definite rule, but are very compact around it. There is no apparent differentiation in size or form in them and, so far as I have observed, the trumpet hyphae are entirely wanting. The outer part agrees in important points with the epidermal layer of the stipe, but is thinner. Cfr. also, WILLE: Beiträge z. physiol. Anat. der Lamin., p. 22. In some species, abundant mucilage glands are found there, even in those species which lack them in the blades of the adult stage.

### *Cryptostomata.*

The cryptostomata found in some members of *Alaria* are not pit-form as in the Fucaceous plants, but shallow depressions of merely one or two cells deep on the surface of frond. In *A. esculenta* GREV., *A. crassifolia* KJELLM., *A. grandifolia* J. AG., etc., they appear as a conspicuous organ scattered on the blade especially in an early post-embryonal stage of frond. In *A. praelonga* KJELLM., *A. tenuata* KJELLM., *A. marginata* P. et R., etc., they are entirely wanting. It is, however, not advisable to separate all *Alaria* into two groups, cryptostomated and non-cryptostomated, and to place too much importance upon the organ for specific distinction is

often misleading.<sup>1)</sup> KJELLMAN<sup>2)</sup> once identified a plant from Alaska with *A. lanceolata* KJELLM. on account of the largeness and abundance of "the tufts of long cryptostomata," though in all other characters it appears to me to be referable to *A. dolichorhachis* KJELLM.

Various opinions regarding the nature and function of cryptostomata have been expressed by different botanists. The opinions, however, have been within the limit of the Fucaceous cryptostomata and did not take into consideration similar organs of the other families. When the tufts of hairs found in Enceliaceæ and Laminariaceæ are equally treated as cryptostomata, the nature and function of the organ become still more inexplicable. MURRAY<sup>3)</sup> says:—"A comparison of the Fucaceous conceptacle and cryptostoma, the *Splachnidium* conceptacle with its persistent initial cell and the formation of its hairs yielding place to sporangia, the development of the *Adenocystis* cryptostoma in the heart of its sorus, the other Laminarian cryptostoma (*Saccorhiza* and *Alaria*) apart from the sorus, the cryptostoma of *Hydroclathrus* among its plurilocular sporangia, and finally the cases of the hairs in *Asperococcus* and the Cutleriaceæ and Dictyotaceæ—a comparison of these cases, and of the evidence plainly furnished by them, points very significantly to a possible origin of cryptostomata."

The development of cryptostomata is now much clearer than at the time when MURRAY's work was published. For the full knowledge on the behavior and further development of the "initial cell" in the conceptacle and cryptostomata of *Sargassum filipendula* we owe to Miss SIMONS' excellent paper.<sup>4)</sup> Her paper largely con-

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1) WILLE: Beiträge z. physiol. Anat. Lamin., p. 37.

2) SAUNDERS: Harriman Alaska Exped., Algae, p. 426.

3) MURRAY: Phycological Memoirs, X, p. 63.

4) SIMONS: Morph. Study of *S. filipendula*.

firms the observations made by BOWER, VALIANTE, OLTMANNs, etc., though there are certain points at variance with them. The mode of formation of the "cryptostomata" of *Alaria* has been fully elucidated by MURRAY.<sup>1)</sup> The present writer<sup>2)</sup> observed parallel cases in those of *Costaria* and *Undaria*. We are now on safe ground when we say that the tufts of hairs found in fronds of Laminariaceæ are different from the cryptostomata of Fuaceæ, genetically and morphologically. MURRAY has already recognized the difference as he expresses hesitation in applying the term cryptostomata to the tufts of hairs of *Alaria*.

MURRAY points out in the above quoted lines a morphological gradation of the cryptostomata of Enceliaceæ, Cutleriaceæ and Dictyotaceæ. His idea appears to me by far suggestive when we take into consideration all other brown algae which bear the hairs, and the development of such plants. I shall take this opportunity to elucidate briefly the embryonal stages of *Homœostroma latifolium* J. AG.

The primary stage of development of *Homœostroma latifolium* J. AG. is a discoidal monostromatic patch of parenchymatous cells (Plate XIX, fig. 5). Some of the marginal cells elongate prostrate-ly to form the rhizoidal filaments. Meanwhile, the patch becomes polystromatic. Some of the surface cells elongate upright, and form confervoid bodies by successive transverse divisions. When there are about 20 cells in a confervoid body the basal cells grow longer than diameter and the middle and upper ones more or less compressed and broader than height. Then a longitudinal division through the median line takes place in the compressed cells. Further multiplications of cells follow next to form a linear, mono-

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1) MURRAY: l. c.

2) YENDO: Development of *Costaria*, etc.



stromatic blade. A sort of segmentation, as it were, can be seen in these stages (Plate XIX, fig. 9). Each segment indicates that the cells in it are derived from the same mother cell, as an areole of the epidermal cells in an embryonal blade of Laminariaceæ.<sup>1)</sup>

While these processes are going on, the apical cell of the confervoid body remains single, but elongates upwards, keeping the initial diameter. As soon as the linear, monostromatic blade has been formed, the elongated apical cell begins to divide by transverse septa and the resulting filament quickly gains its length by basipetal growth (Plate XIX, fig. 8, 9). It shows all the characters of the hairs peculiar to the Phæophyceæ. Something quite similar was observed by REINKE<sup>2)</sup> in the sporelings of *Scytosiphon pygmaeus*. From the uppermost marginal cell of each segment there starts a similar hair. Plate XIX, fig. 10 shows a marginal part of a blade of about 3 mm. in length. In it, hairs at various stages of development are found in considerable number, but not in tufts. They are thicker than the primary hair at the apex of the blade but undoubtedly are of the same nature. The tufts of hairs on the surface of the blade, mentioned in describing the species, come out in a much later stage.

A filament resembling the apical hair of the treated plant is delineated by THURET<sup>3)</sup> for the sporelings of *Stilophora rhizoides* J. AG. It is to be remembered that the species is characterized by having a single persistent hair at the apex of the frond.

Summing up the results hitherto obtained from the observations on the adult forms of the Phæophyceæ, we may distinguish the modes of occurrence of the hairs and their relative positions

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1) YENDO: Development of *Costaria*, etc., Pl. LIV, fig. 19.

2) See ENGLER und PRANTL: Pflanzenfamilien, Algae, fig. 139, c.

3) THURET: Zoospores des Algues, Pl. 28, fig. 9.

to the sporangia in the following manner:—

1. Both hairs and sporangia isolated, dispersed on the frond without any definite order; no definite relation between their positions of occurrence.

Striariaceæ, Dictyosiphonaceæ, Desmarestiaceæ.

2. Hairs more or less aggregated in tufts; sporangia more or less localized into sori; no definite relation between their positions of occurrence.

Enceliaceæ (*Punctaria*, *Homœostroma*, *Phyllitis*, etc.).

3. Hairs aggregated in tufts; sporangia only around the hair-tufts.

Enceliaceæ (*Asperococcus*).

4. Hairs isolated, or more or less aggregated; sporangia at the bases of the hairs, assuming the positions of branches.

Chordariaceæ, Spermatocnaceæ, Cutleriaceæ, etc.

5. Hairs aggregated in tufts, in small depressions on the surface of frond; sporangia localized to form the sori in a more or less definite part of frond; no definite relation between the positions of hair-tufts and sori.

Laminariaceæ (*Alaria*, *Undaria*, *Agarum*, etc.).

6. Hairs aggregated in tufts, in small pits on the surface of frond; sporangia limited to the pits in a certain fixed part of the frond.

Fucaceæ.

From a birdseye view of the various modes of occurrence of the hairs, and their relative position to the sporangia as arranged above, we may trace the apparent gradations in the localization of both organs from the isolated hairs and sporangia to the conceptacles of Fucaceæ. If the view that the ontogeny repeats the phylogeny is to be accepted, the observation on the hairs of the

embryonal frond of *Homæostroma* will illustrate the evolution of Encoeliaceæ from a more primitive form such as Striariaceæ.

As for the cryptostoma of Fucaceæ, it may be explained to be a sterile conceptacle according to BOWER<sup>1)</sup> and SIMONS<sup>2)</sup>. Or, according to OLTMANNS<sup>3)</sup> view, the conceptacle may be a fructified cryptostoma. But BARTON'S<sup>4)</sup> view that "the two forms of conceptacles are of equal antiquity, and were a later development in the ancestors of the Fucaceæ than the reproductive organs," may be open to criticism. We know very little, if anything, about the ancestors of Fucaceæ. If, however, ontogeny repeats phylogeny, the tuft of hairs in the apical pit of the sporelings of *Fucus* suggests to us to prefer the view that the cryptostoma is an important vegetative organ of the Fucaceous frond and that its development is earlier than that of the conceptacle.

MURRAY<sup>5)</sup> says:—"I am aware that the hairs of the cryptostomata are regarded by many as adapted to absorptive and other nutritive functions. This may or may not be; there is no proof of the matter, and probably more reasons to be cited against than in favour of, such an opinion." He has not treated the matter further and we are not able to know what was his opinion regarding the functions of the hair-tufts of *Alaria*. The view held by some botanists, that the hairs of the Phæophyceæ are a protecting organ against the light is undoubtedly derived from the accounts of the hairs of the Phanerogams. This can be readily denied when we consider the fact that the blades of the Phæophyceæ which are habitually decumbent have the hairs developed on

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1) BOWER: On the Development of Conceptacles in the Fucaceæ, p. 37.

2) SIMONS: Morphol. Study of *Sarg. filipendula*, p. 174.

3) OLTMANNS: Beiträge zur Kenntnis der Fucaceen, p. 82.

4) BARTON: On the Genus *Turbinaria*, p. 223.

5) MURRAY: Phyc. Memoirs, X, p. 63.

both surfaces equally rich, and that in one and the same species found either in shade or in light, the hairs show no difference in their number and size.

As mentioned above, the hairs in the Phæophyceæ make their appearance at a very early stage of development of the frond. In some member they are persistent, though the cells composing them are constantly renewed by the basipetal growth; in others, they are present while the frond is not fully matured or is in an embryonal stage. In *Homœostroma*, as above observed, there are a large number of isolated hairs on the margins of the embryonal blade; they drop off as the blade grows and the tufts of hairs appear on the surface of the blade (Plate XIX, fig. 12). The renewal of the hairs and their shedding in the adult fronds are ample proof that the hairs are not directly related to the reproduction. In a dilute solution of life-staining material (for instance, 0.1% aqueous anilin blue in sea-water) the hairs absorb the colouring matter without plasmolysis taking place in the cells while the epidermal cells take in no trace of it. There may be no direct proof that the hairs of the Phæophyceæ are absorptive organ, but there is nothing against the view, so far as I am aware, in explaining them as adapted to it.<sup>1)</sup>

Whatever it may be in other families, the hair-tufts in the Laminariaceous frond can safely be regarded as a sort of absorptive organ. The appearance of the hairs on the frond begins at an early stage of development.<sup>2)</sup> The hairs are in a most vigorous state of growth just before the formation of the sori. When the plant has attained full maturity, the hairs are mostly broken off,

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1) REINKE: Kenntniss der Tange, p. 321.

WILLE: Beiträge z. physiol. Anat. der Lamin., p. 39.

2) MURRAY: Phycol. Memoirs, X.

YENDO: Development of *Costaria*, etc.

leaving but aggregations of the small basal cells as dark spots on the blade.

Thus, the hairs in the fronds of Laminariaceæ appear to me to be an absorptive organ as are the isolated hairs in the other Phæophyceæ. They are localized to form tufts more or less resembling in appearance the cryptostoma of Fucaceæ. The hair-tufts of Laminariaceæ, Dictyotaceæ, Enceliaceæ, etc., have been proved to be genetically different from the Fucaceous cryptostomata. Hence, it should be an improper idea to regard the latter as the most advanced form of the hair-tufts. However much they differ from the other Phæophyceous hairs in their mode of formation, they may be taken equally well as an absorptive organ. In Fucaceæ the sporangia are localized in the hair-pits of a certain part of the frond, called receptacle, the hair-pits in the vegetative parts are named cryptostomata, and those in the receptacles, conceptacles. It is quite natural to meet with "the occasional appearance of sterile representatives of sexual organs within the cryptostomata."<sup>1)</sup>

In *Alaria*, the hair-tufts occur on the whole area of both surfaces of the blade, except the stipe, the midrib and the soriferous area of the sporophyll. The transition region of the blade is usually devoid of them, perhaps because all the cells in the area are meristematic. In most cases, certain areas of the blade along both sides of the midrib are also free from them. As the frond develops further, the scars of the withered hair-tufts are stretched in the direction of the expansion of the blade, *i.e.*, parallel to the clefts, resulting in elongated elliptical flecks. The sporophylls of the Metasoria are provided with the hair-tufts while they are functioning as vegetative organs, if the blade of the respective frond has them (cfr. p. 25).

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1) SIMONS: Morphol. Study of *Sarg. filipendula*, p. 174.



In “non-cryptostomated” members we often find minute dark brownish spots in the upper portion of the frond. They very much resemble, in mode of occurrence as well as in anatomical characters, the scars of the withered hair-tufts. In some cases they are results of an accidental death of epidermal cells, the space being filled up by quick multiplication of the surrounding cells which continues as long as the part concerned extends as the blade develops. In others, they are remains of the mucilage glands, as stated below. While the frond is yet young, the nature of such elliptical spots may be ascertained by the presence or absence of the hair-tufts in other parts of the frond. But in a matured and old frond in which no more functionate hairs are to be found, we are often puzzled to determine whether the plant is “cryptostomated” or “non-cryptostomated.” This is especially the case in the dried herbarium specimens.

From the above statements it may be readily granted that the presence or absence of the hair-tufts is often difficult to ascertain in an old fragmentary specimen; and also that the length or number of the hairs in a tuft is variable and hence of no specific importance. Yet when we are able to collect a large number of specimens of a certain species it is always advisable to make a careful observation of them. In some cases, we find a few hair-tufts in the frond of a species which is properly “non-cryptostomated” in the typical form. Cfr. description of *A. prælonga*, p. 85.

### *Mucilage Glands.*

The presence of the peculiar glandular cells in fronds of *Laminaria Peterseniana* KJELLM. was first noted by OKAMURA<sup>1)</sup> who took

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1) OKAMURA: On Laminaria of Japan, p. 98.

them to be a kind of "excretory organ." MIYABE<sup>1)</sup> found a similar organ in *Undaria pinnatifida* SUR., and the present writer<sup>2)</sup> in *Hirrome undarioides* YENDO. Afterwards, I described the cells in detail<sup>3)</sup> and expressed the view that these cells are mucilage glands. SAUVAGEAU<sup>4)</sup> noticed quite similar cells in the embryonal fronds of *A. esculenta* GREV. and was inclined to regard them as a reservoir of fucosan grains, but stated at the same time that it is a noticeable fact to find them in the lacunae-wanting members of Laminariaceæ.

I have also noticed the presence of the mucilage glands in various species of *Alaria* in the course of the present study. The glands have been carefully examined on *A. crassifolia* KJELLM., as its fresh material is most easily accessible to me. SAUVAGEAU's observation on the glands of *A. esculenta* GREV. is by no means exhaustive. The following remarks on those of *A. crassifolia* will not be unnecessary for future investigators on the subject.

The smallest specimen of *A. crassifolia* with the mucilage gland, as far as I have observed, was 2.2 mm. in total height. The frond was lanceolate with a cylindrical stipe of moderate length, and the blade measured 0.61 mm. at its broadest part. The upper part as well as the marginal area of the blade remained still in the monostromatic state. The mucilage glands were mostly found at the boundary between the monostromatic and the polystromatic area, in a few but irregular rows. Surface views of the glands were mostly circular, but some in the upper part of the blade more or less longitudinally stretched. The apertures of the small circular glands were little more than the size of single

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1) YENDO: Three New Mar. Algae. from Japan, p. 102.

2) YENDO: l. c.

3) YENDO: On the Mucilage Glands of *Undaria*.

4) SAUVAGEAU: Sur les "Glandes a Mucilage" de certaines Laminaires, p. 12.

epidermal cell, but those of the stretched ones nearly as large as two or three epidermal cells taken together. A number of the glands have also been found on the surface of the stipe.

As the embryonal blade elongates further by stipo-frondal growth, the monostromatic part is eroded away by degrees. This generally takes place when a frond has attained 6–7 cm. in total length. At this stage, the mucilage glands are much denser than in the preceding stage, and much larger in size and greatly elongated. Very frequently, two, three or more of the elongated glands are found continuous together, forming a simple or ramified passage. See Plate XVIII, figs. 9–11. The small circular ones may be seen near the transition region only and along the very margins of the blade. The content of the gland is granular and colourless. The glands in the stipe undergo no marked change in their shape and size.

When the frond has grown to measure more than 12 cm. in total length, the contents of the older mucilage glands turn into a dark brownish colour even in the living material. In general, the glands in the region up to 20–30 mm. from the transition region are colourless and granular; but those in the upper parts of the blade, except the newly formed young ones, are all brownish (Plate XVIII, figs. 8–10).

The longitudinal stretching of the glands while yet young, appears to follow the longitudinal elongation and the multiplication of the epidermal cells. This can be concluded from the fact that the disposition of the epidermal cells is not at all disturbed upon or around the glands. But in the later stages, generally after the content has turned into a dark brownish mass, the glands gain in width and the epidermal cells around the opening become radially disposed (Plate XVIII, fig. 9, a). In *Undaria pinnatifida*, the

glands gain their size by expanding in all directions, hence the epidermal cells have to be arranged radially at an early stage of development of the glands.<sup>1)</sup> This difference may be easily explained from the modes of growth in the two plants. In *Undaria*, the pinnae extend in area by the growths in length and width, but in *Alaria*, the embryonal blade grows much quicker in length than in width.

I<sup>2)</sup> have already mentioned the difference in number of the glands in the marginal and the middle part of the frond of *Undaria*. In the former part there are always more numerous glands than in the latter. In *Alaria crassifolia*, the glands are practically limited to the margins of the blade (Plate XVIII, fig. 8).

When the fronds of *A. crassifolia* have attained the length of 50–60 cm. and the sporophylls make their appearance as small ligules, there are very few glands, if any, to be found in the transition region or in any other part of the blade. But in the membranous sterile part of the sporophylls, which are to be found in a further advanced stage of frond, the mucilage glands are very well developed.

In *A. fistulosa*, the largest form among the genus, the glands may be seen all over the blade, except the midrib, even after the numerous sporophylls have appeared.<sup>3)</sup> The glands of this species are not stretched longitudinally as in *A. crassifolia*; those in the transition region are nearly as round as those of *Undaria*, and those in the part about a meter or so above the transition point

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1) YENDO: On Mucilage Glands of *Undaria*, Plate XLVIII, fig. 7.

2) Litto, p. 614.

3) Miss KIBBE observes a peculiar sort of cells in the frond of *Alaria fistulosa* and regards them as a fungus. I am inclined to doubt her observation; she may have mistaken the glandular cells as a parasite. (Puget Sound Marine Station Publication, Vol. I, No. 20 1916). In her previous paper (the same Publication, Vol. I, No. 8, 1915) specially treating on the structure of *Alaria fistulosa* she gives no account on the remarkable glands.

—the part near the base of the blade in proportion to the whole length, which measures 10–20 meters when the sporophylls begin to appear—are *transversely* stretched. Remember that the young and sterile frond of this species may have the blade 10–20 meters in length and 20–30 cm. in breadth, and when nearly matured the blade is fully one meter broad. This shows that the blade, after it has completed or nearly completed its growth in length, must extend its breadth with an astonishing speed. More stretching in the transverse direction than in the longitudinal, is naturally to be expected. This is indicated by the disposition of the epidermal cells and by the transverse stretching of the glands.

SETCHELL and GARDNER stated in their joint work, *Algae of the North-western America*, p. 276, that the stipe of *A. fistulosa* “seems to be free from mucilage ducts, but the blade in both forms (f. *stenophylla* SETCH. and f. *platyphylla* SETCH.) possesses abundant structure of this kind, just under the outer layer of cells, as GUIGNARD has indicated.” But so far as I have examined Japanese material I could not find true mucilage ducts in the frond of *A. fistulosa*.

I will take this opportunity to say a few words on GUIGNARD's observation directly concerning this subject. He disproves the presence of the “cavité mucifère” in the frond of *Undaria pinnatifida* SUR. (= *Ulopterix pinnatifida* KJELLM. = *Alaria pinnatifida* HARV.). It will clearly be understood that the brownish spots frosted all over the blade of this plant did not attract his attention. He mentions two species of *Alaria*, *A. esculenta* GREV. and *A. grandifolia* J. AG., as lacking the mucilage canals. He did not examine the embryonal fronds of these species. Lastly, he points out the presence of “canaux mucifères très gros et très nombreux



dans toutes les parties de la lame" of *A. fistulosa*.<sup>1)</sup> The remark by SETCHELL and GARDNER refers to these lines.

GUIGNARD's observation on the mentioned species have all been done on herbarium specimens. It is rather excusable that he has mistaken the mucilage glands of *A. fistulosa* as the mucilage lacunae, and overlooked the similar but smaller cells in the fronds of *Undaria pinnatifida*. His statement disproving the conclusion by KJELLMAN<sup>2)</sup> that *Alaria* plants have no mucilage canals is therefore to be re-disproved.

In a fully matured frond of *A. ochotensis* YENDO the transition region is so rich in the roundish glands as to turn the part of the blade, when dried, into a dark reddish-brown colour. In the upper part of the blade as well as in the membranous sterile part of the sporophylls, the glands are much elongated, furcated and armed with short lateral processes, and a few of them are often fused together (Plate XIX, figs. 2-3). The mucilage lacunae of *Laminaria* occur in some species, for example, *Laminaria angustata* KJELLM., in detached groups of incomplete network.<sup>3)</sup> The mucilage glands of *A. ochotensis* approach in general aspect, though of course genetically differing from, the mucilage lacunae of *L. angustata*. It is too complicated for a fucosan reservoir.

The mucilage glands of the other species of *Alaria* have more or less fixed character in each. The three examples described above illustrate extreme cases of the primitive and well-developed state of the glands. Under the descriptive part some accounts of the gland of each species will be given, referring to the above remarks.

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1) GUIGNARD: Observations sur Appareil Mucilère des Laminariacées, p. 43.

2) KJELLMAN: Handbok i Skandinaviska Hafsalgöra, p. 19.

3) MIYABE: Laminaria Industry of Hokkaido, Plate 29, fig. 5.

*Monstrosities of the frond.*

I. Duplication of blade. In one of the specimens of *A. taniata* KJELLM. in the Herbarium of the Hokkaido Imperial University, Sapporo, one side of the blade is totally doubled, that is to say, two semi-blades are present on one side of the midrib. They are equal in shape and size and are symmetrical with the opposite, single semi-blade. A transverse section near the transition point shows the sheering of the medullary portion into equal parts at its marginal swelling. The semi-blade is duplicated from the ordinary crucial point between the midrib and the blade, with a narrow but roundish sinus in the section. The spanning cortex is found in the normal position but not newly formed for the inner side of the semi-blade (Plate XVI, fig. 4). The two semi-blades run parallel in the usual direction. They have the same thickness as the single semi-blade and all elements of the tissue are represented in due manner and proportion.

I can not find any evidence explaining the cause of this abnormality. In the transition region there is no symptom of deformation, there simply being two ridges instead of one to indicate the future development into two semi-blades. The terminal portion of the frond is eroded so that nothing can be induced therefrom.

KUCKUCK<sup>1)</sup> has observed the duplicate blades in *Laminaria saccharina*. KILLIAN<sup>2)</sup> also notes "Flügelbildung" of a blade in *Laminaria digitata*.

II. Ramification of Stipe. In *A. praelonga* KJELLM. and *A. lanceolata* KJELLM., we meet very often with a bifurcated stipe. The bifurcation always takes place, as far as our material shows,

1) KUCKUCK: Bemerk. zur Mar. Algenveg. von Helgoland, p. 248, fig. 18.

2) KILLIAN: Beitr. zur Kenntn. der Laminarien, p. 472, fig. 26.

at a point in the sporophyll-bearing region of the stipe, and is by the median plane. Judging from a very young frond which has a clearly divided stipe, the abnormality appears to have been caused by a certain influence at a point just below the transition point. The frond develops further adding a length to the stipe and thus shifting the affected point further below the transition point. In all specimens with such abnormality the two arms are nearly parallel with very narrow sinus and have equal values. The sporophylls may be found on the outer edges only of the two arms or on both edges as well, and also below the furcation (Plate IV, figs. 4, 5). Similar cases have also been reported by SETCHELL<sup>1)</sup> on *A. esculenta* GREV., collected by COLLINS on the coast of New England. In some examples the sporophylls are not particularly different in number and size from the normal form, but in many cases, only a few of them, very irregular in size, are to be found.

The blades on the two arms are not especially smaller than the normal ones. In one case, however, one of the two blades was destitute of its inner half, in spite of the midrib being as broad as that of the complete blade.

III. Other monstrosities. Besides the two kinds of monstrosities mentioned above there are various examples of deformation, but of less importance. One of the common cases is the spiral twisting of the sporophylls. This is undoubtedly caused by a checking of growth in one side of a sporophyll while the other side develops at normal speed. It may be due to an internal cause in the tissue of the sporophyll or by an animal feeding on the plant. In the Holosoria the spiral turning is mostly found at the terminal portions of the sporophylls.

Bifurcation of a sporophyll is also not rarely met with. An

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1) SETCHELL: Regeneration among Kelps, p. 149.

upper portion of a sporophyll divides into two segments with broad and round sinus. The resultant segments are sometimes of equal value, but sometimes one of them appears as if ramified from the other.

Species which have in normal condition smooth blades, may sometimes be found with transverse corrugation along both sides of the midrib. Examining closely we find generally in such case numerous parasitic crustacea, mostly of species belonging to Gammaridae, living in the midrib. The little creature digs a labyrinthic tunnel through the medullary and subcortical tissue of the midrib. This causes the retarding of the growth in length of the midrib. As the blade is in no way infected by the parasite, the unequal speed of growth in length of the two parts results only in the corrugation.

### Development and Life History of *Alaria*.

The recent investigations on the embryonal stages of *A. esculenta* GREV. and some species of *Laminaria* by DREW,<sup>1)</sup> KILLIAN,<sup>2)</sup> SAUVAGEAU,<sup>3)</sup> etc., have greatly changed the view hitherto held by modern botanists on the life history of the Laminariaceous plants. We are now aware that the zoospores liberated from the unilocular sporangia of the sori of the Laminariaceae do not directly develop into the well known, large forms of fronds, but germinate into microscopic protonema-like bodies. The latter are sexual and dioecious, *i. e.*, either male or female gametophytes. From the oogonium an embryonal frond starts which may develop into the large form commonly known as a Laminariaceous plant. Thus in

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1) DREW: Reproduction and Early Development of *Lam. dilatata*.

2) KILLIAN: Beiträge zur Kenntn. der Laminarien.

3) SAUVAGEAU: Sur les plantules de quelque Laminaires.

the species investigated, very probably in all members of the Laminariaceæ, there is an alternation of generation with the conspicuous asexual form and the microscopic sexual.

When I<sup>1)</sup> described *Hirome undarioides* as a new species, I expressed the view that the plant stands as an intermediate form between *Undaria pinnatifida* SUR. and *Laminaria radicata* KJELLM., in its habit, texture and propagating organs; and that an explanation of the genetic relationships between them may be facilitated if hybrids of Laminariaceous species have been proved possible. In the specific determination of other members of Laminariaceæ the same is to be observed. The late discovery is from this point of view highly interesting and important.

The early embryonal stages of the fronds of the Laminariaceous plants have also been carefully studied by DREW,<sup>2)</sup> and by KILLIAN<sup>3)</sup> on *Laminaria digitata*, by SAUVAGEAU<sup>4)</sup> on *Laminaria saccharina*, and by myself<sup>5)</sup> on *Costaria Turneri* and *Undaria pinnatifida*. Of the later stages, there are works by BARBER,<sup>6)</sup> SETCHELL,<sup>7)</sup> REINKE,<sup>8)</sup> McMILLAN,<sup>9)</sup> GRIGGS,<sup>10)</sup> KYLIN,<sup>11)</sup> etc., on various species. By these studies our knowledge on the development of the frond of Laminariaceæ has been much amplified than in before. There remain, however, some points for further study on the life history of various species, if not of the majority. The question

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1) YENDO: Three New Mar. Algae from Japan, p. 102.

2) DREW: Reproduction and Early Development of *L. saccharina* and *L. digitata*.

3) KILLIAN: Beiträge zur Kenntn. der Laminarien.

4) SAUVAGEAU: Sur les Plantules de quelq. Lam.

5) YENDO: Development of *Costaria*, etc.

6) BARBER: On the Structure and Development of the Bulb in *L. bulbosa*.

7) SETCHELL: On the Life History of *Sacchorhiza*.

8) REINKE: Studien z. vergleich. Entwicklungsgeschichte der Laminarien.

9) McMILLAN: Observation on *Pterygophora*.

10) GRIGGS: Juvenile Kelps and the Recapitulation Theory.

11) KYLIN: Über den Generationswechsel bei *Laminaria digitata*.



whether *Alaria* sheds its blade periodically, for instance, appears to me to be yet unsettled.

The gametophyte stages of *A. crassifolia* I have also studied from living material collected in the field. Owing to a considerable number of strangers always associated with the sporelings of the plant, it was not easy matter to trace the stages of development in a satisfactory manner. The sterile fronds of *Microspha*(?), *Myrionema* and *Eclocarpus*, which are found growing with the sporelings, have been especially embarrassing. Unfortunately I could not find any sporophyte directly starting from a gametophyte.

The earliest stage of development of the sporophyte which I observed was two-celled (Plate XVIII, fig. 4). The lower cell was cylindrical, measuring  $8\mu$  in diameter about  $26\mu$  in length with the basal end slightly crooked. It had no special content except fine granules and colourless plasma. The upper cell was similarly cylindrical with roundish apex, and measured  $9\mu$  in diameter,  $26\mu$  in length. Disc-shaped chromoplasts compactly lined the inner surface of the wall, and a few highly refracting grains were present. In both cells the nuclei were not visible before staining. As far as the blade is composed of a single layer of cells, the frond in a more advanced stage is essentially similar to that of the corresponding stage I have observed in *Costaria Turneri*.

In elucidating the development of *Costaria Turneri* and other Laminariaceous plants, I<sup>1)</sup> have pointed out that:—the growth of the early embryonal, monostromatic fronds is mainly due to the activity of the subapical cells, and that of the later polystromatic fronds, to the activity of the transitional region. KILLIAN'S<sup>2)</sup> observation on the development of *Laminaria digitata* agrees with mine

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1) YENDO: Development of *Costaria*, etc., p. 713.

2) KILLIAN: Beiträge zur Kenntn. der Laminarien, p. 447.

in the important points in this respect. He distinguishes a marginal meristematic tissue at the transition region of the post-embryonal frond, by virtue of which the blade increases in breadth.

SAUGAVEAU<sup>1)</sup> discredits the presence of any special tissue which functions for the increase of breadth of the frond and says:—"Le cloisonnement intercalaire dispersé est donc général; il entraîne l'accroissement en longueur et en largeur de la lame et il ne peut être question de méristème marginal." As far as I have observed in the development of various species of Laminariaceæ, the growth in length as well as in breadth of the post-embryonal fronds is due to the activity of the transition region. The region acts for the addition to the length of frond while in its younger stages, and then to the breadth. There is no specialization of tissue for either. The same region acts for both, but more or less separately in time. At the same time, however, it must not be overlooked that the whole part of the blade widens and thickens in itself by cell-multiplication. The areolar arrangements of the epidermal cells, and the changes of shapes of the mucilage glands according to the part of frond, give positive evidence of this fact. Certain differences in the rate of cell-multiplication may be found according to the parts. The undulation or crispation of the margins of the frond which is quite plane or less waving while young, is due to the greater rate of growth along the margins after the length of frond has been completed by the stipo-frondal growth. The transverse wrinkles along the midrib of *Alaria* and *Undaria*, the undulations in the fronds of *Costaria* and certain *Laminaria* may be explained in a similar way. The subulate and reflexed tips of the split segments of *A. angusta* (Plate XV, fig. 2) can hardly be interpreted unless a partial extension of the segments after the

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1) SAUVAGEAU: Plantules de quelque Laminaires, p. 19.

splitting is admitted to have taken place (cfr. p. 11). Yet there is no doubt that the principal growth of the fronds, in length and in breadth, of the Laminariaceous algae results from the activity of the transition region, where the meristematic tissues are located.

Soon after the precortical layers make their appearance in the transition region, the embryonal fronds of *Alaria* begin to reveal some of the generic peculiarities in a primitive state, *i. e.*; 1), the mucilage glands frosted about the boundary between the monostromatic and the polystromatic area: 2), formation of the midrib. These two peculiarities can be perceived when a frond has attained the total length of 6–7 mm. In this respect the embryonal fronds of *Alaria* resemble those of *Undaria* most. Both are, however, distinguishable by the difference of germinating seasons, formation of the pinnules at the transition point and by the localities of the species. The embryonal fronds of *Undaria* appear early in January in northern Japan, and earlier in middle and southern, while those of *Alaria* are found in March–May. In *Undaria* the formation of the pinnules takes place at the transition region soon after the blade has grown to the length of 2 cm. or so. Species of *Alaria* are limited to the eastern coasts of northern Japan while *Undaria* is limited to the west coast of the Hokkaido and to both sides of the Main Island. But in the vicinity about the Tsugaru Strait, where *Undaria pinnatifida* and *A. crassifolia* occur living together, separation of the plants by the last mentioned point is of course unreliable.

The appearance of the sporophylls takes place in most species in June–July, varying according to the germinating time of the sporophyte frond. The first few sporophylls remain less developed in size when compared with the successive upper ones (Plate IX, fig. 1). New sporophylls come out continuously upwards on both edges of the stipe till the later part of spring. These sporophylls

which appear early may be soriferous late in summer or early in autumn, but the liberation of the zoospores begins, on an average, in autumn between October and November. They then drop off from the petioles, leaving verrucose scars on the stipe. During winter, the upper sporophylls develop only a little. In early spring they begin to develop quickly and the sori on them ripen continuously until the entire frond is uprooted in the middle of summer. The sporophylls which are formed at a later period in the life of the frond remain undeveloped and must follow the fate of the frond, becoming useless before they can exercise their proper function (Plates IX and X).

How, then, does the blade pass through the winter? Does *Alaria* shed its blade periodically?

*A. esculenta* GREV. has been the subject of this discussion among the European algologists as the species is easiest accessible to them for observation. BÖRGESEN<sup>1)</sup> wrote a paper specially devoted to the question and enumerates the views of many former writers. Beside those mentioned by him, DAWSON TURNER<sup>2)</sup> remarks that *Fucus esculentus* is perennial, though he does not touch the subject in question directly. RUPRECHT<sup>3)</sup> repeated the words "ein-jährige Exemplare" in describing the North Pacific *Alaria*. It may be taken as evidence that he believed the *Alaria* plant to live more than one year. SETCHELL and GARDNER<sup>4)</sup> in their joint work report the presence of the "rings of growth" in the stipe of *A. valida*. ROSENVENGE<sup>5)</sup> does not actually say that *Alaria* is perennial, but he illustrates the shedding of the old blades in his specimens.

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1) BÖRGESEN: Note on the Question whether *A. esculenta* sheds its Lamina, &c.

2) TURNER: Historia Fucorum, Tab. 117.

3) RUPRECHT: Tange des oeh. Meeres, p. 355.

4) SETCHELL and GARDNER: Alg. N.-W. Amer., p. 278.

5) ROSENVENGE: On the Marine Algae from Northeast Greenland, p. 113, fig. 5.

BÖRGESSEN<sup>1)</sup> discredits the annual shedding of the blade and sticks to the opinion that the blade of *A. esculenta* elongates continuously by stipo-frondal growth, its upper part wearing by degrees and so keeping nearly the same length. PHILLIPS<sup>2)</sup> and OLTMANNS<sup>3)</sup> are not very far from this view.

Summing up the statements of the previous writers, I understand them to be classifiable briefly as follows:—

- (1). *Alaria* plant is perennial.

TURNER: Historia Fucorum. (on *A. esculenta*). 1809.

RUPRECHT: Tange des oeh. Meeres. (on *A. fistulosa* and *A.* sp.). 1850.

?SETCHELL and GARDNER: Algae of N.-W. America. (on *A. calida*). 1903.

- (2). *Alaria esculenta* is perennial and sheds its blade annually.

HARVEY: Phyc. Brit., I. (sporophylls also). 1846.

JOHNSTONE and CROALL: Brit. Seaweeds, III. (Sporopylls also). 1859.

ARESCHOUG: Observ. Phyc., V. 1884.

KJELLMAN: Handbok i Skandinav. Hafsalgflora, I. 1890.

WILLE: Beitr. z. Physiol. Anat. der Laminariaceen. 1897.

REINKE: Stud. z. vergl. Entwicklungsgesch. der Laminarien. 1903.

ROSENVENGE: On Mar. Algae from N.-E. Greenland. (on *A. grandifolia* J. Ag.). 1910.

- (3). *Alaria esculenta* does not shed its blade periodically.

PHILLIPS: Notes on *Sacc. bulbosa* and *A. esculenta*. 1896.

BÖRGESSEN: The Mar. Algae of Faeröes. 1904.

1) BÖRGESSEN: Note on the Question whether *A. esculenta* sheds its Lamina, &c.

2) PHILLIPS: Notes on *Sacch. bulbosa* and *A. esculenta*.

3) OLTMANNS: Morph. und Physiol. der Algen.



BÖRGESSEN: Note on the question whether *A. esculenta* sheds its Lamina periodically or not. 1904.

OLTMANN'S: Morph. und Physiol. der Algen. 1904.

In various herbaria in Europe which I have visited, there was no specimen of *Alaria* to give any evidence in support of the view that the plant is perennial and sheds the blade periodically. I have seen a single specimen with a constriction in the blade in the Herbarium of Trinity College, Dublin. The specimen was collected by NOLT and sent from SONDER under *Laminaria Noltii* Ag. At the constricted point the blade becomes quite narrow, measuring but a few millimeters on both sides of the midrib. From this point the blade expands to its normal breadth, more or less abruptly upwards and comparatively gradually downwards. The substance of the blade in the two parts has no marked difference, therefore not justifying the view regarding the upper part as having grown at quite a different season from the lower. The midrib is in substance, thickness and breadth uniform throughout the whole length. The statement made by HARVEY in Phyc. Brit., Plate 79, about the regular change of the blade of *A. esculenta*, however, seems not to have been derived from this specimen.

ROSENVENGE<sup>1)</sup> gives photographs of two specimens of *Alaria* from Greenland, each with a remnant of the old blade at the top of the new. They may be taken as full proofs of the renewal of the blade of *Alaria* but not of the perennial existence of the plant.

On the coasts of Japan, most *Alaria* attain their full maturity in summer. The species which inhabit the comparatively warmer waters, such as *A. crassifolia* and *A. praelonga*, discharge the spores during July–August with the utmost vigor; and the fronds are entirely washed away from the substrata before the end of

1) ROSENVENGE: On the Mar. Alg. from N.-E. Greenland, p. 113, fig. 5.

September. How the zoospores behave after they are freed from the sporophylls is not satisfactorily known to me.

The question whether the zoospores of the Laminariaceae plants rest for a certain period after liberation, or germinate soon and pass a considerable time in the state of a protonema-like body, is not yet satisfactorily solved. The young sporelings of *A. crassifolia* are met with between March and May. Late in March, on the coasts about the Tsugaru Strait, bunches of embryonal fronds of this species may be found on rocks, barnacles, mussels, other larger algae or on the sheaths of *Potamilla myriopus* in the sublittoral region. Taking one of these bunches we find some fronds already as large as 30–50 cm. in length while some are microscopic, and even protonema-like gametophytes are still associated with them (Plate XVIII, figs. 1–3). This lack of uniformity in the time of outsprouting may perhaps be due to the fact that the spores are discharged during a considerable range of time, as the sporophylls attain their maturity successively from the lowermost upwards, and eventually the spores from the basal sporophylls develop earlier than those from the upper ones. At least in *A. crassifolia*, the maturing of the sporophylls takes place twice in the life of the plant. I will treat of this further below. The other species found in colder waters, *i.e.*, in the northern part of the Kurile Islands or in Sakhalin, are very likely similar in this respect. Their fully matured fronds are found during August–September, and the sporelings are mostly met with in April–June. According to KJELLMAN,<sup>1)</sup> the blade of *A. grandifolia* is shed at Spitzbergen in winter. ROSENVENGE<sup>2)</sup> observed the same in north-eastern Greenland.

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1) KJELLMAN: Spitzbergens Thalphyter, II, p. 11.

2) ROSENVENGE: On the Mar. Alg. from N.-E. Greenland, p. 114.

The first-year fronds of *Alaria* found in summer have generally much narrower and thinner blades when compared with the second-year ones. Some of them may have small sporophylls which become soriferous and discharge the spores late in autumn.<sup>1)</sup> The thin and narrow blade is worn away for the greater part of its length.

In the following year, during March and April in the warmer parts and gradually later in the colder north, the blade begins its sudden growth, and sporophylls of normal size make their appearance above the smaller ones of the preceding year, quickly increasing in number successively upwards. The sporophylls of the preceding year drop off one by one from below, leaving verrucose scars on the stipe (Plate X). The blade now built up is thicker in substance and darker in colour than that of the preceding year. The sporophylls attain their full maturity in the latter part of spring and then the life of the plant terminates within a few months. Thus it exists for two whole years, but not longer.

The life history alluded to above holds good, as far as I could find, for all species found within our boundaries. Even such a gigantic form as *A. fistulosa* shows only a slight modification if any. The marvelous size of the blade of this species is therefore nothing but the result of the speedy growth during 5-6 months.

As far as I could refer to, full evidence for the perennial life of the *Alaria* plants has never been positively given by any algologist, although there have been many who describe them to be perennial. WILLE<sup>2)</sup> relates:—"Dass im Stipes ein sekundäres Längenwachstum vor sich geht, jedenfalls oben und bis unterhalb der ältesten Sporophyllen, konnte mit Sicherheit an Exemplaren nach-

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1) WILLE: Beiträge z. physiol. Anatom. der Laminariaceen, p. 16.

2) WILLE: l. c.

geweisen werden, welche drei Reihen von Sporophyllen hatten und somit wenigstens vier Jahre alt gewesen sein mussten, da man wohl voraussetzen darf, dass Individuen von *Alaria esculenta* (L.) GREV. keine Sporophyllen erzeugen, bevor sie wenigstens ein Jahr alt sind." There is no doubt that the stipe of *Alaria* elongates by the secondary growth. But how the "drei Reihen von Sporophyllen" could be distinguished in a matured form of *A. esculenta* GREV. and how they could be applied for the estimation of the age of an *Alaria* plant, I have no idea.

BÖRGESSEN<sup>1)</sup> denies the periodical sheddings of the blade of *A. esculenta*. He states that "the leaf keeps on growing at its base during the greater part of the year, while the apex is continuously so to speak worn away by the waves." He seems to have omitted to mention the life-length of the plant. But it may be understood from what he states that he thinks the plant perennial. In The Algae-vegetation of the Färöese coasts he seems also to have said nothing about the stages of development of *A. esculenta* GREV. in different seasons, though he repeatedly touches on it in describing its habit. In explaining Plate XIX of the work, he writes:—among the *Himanthalia* are young *Alaria esculenta*, and ...." I should like to know how young they were, whether sporophyll-bearing or not. I agree of course with BÖRGESSEN in denying the periodical shedding of the blades of *Alaria*, if he means by periodical more than once in the whole life of a plant at certain fixed intervals. It is a fact with our species of *Alaria* that the first-year blade is for the greater part worn away during the winter and only a certain portion remains to be shed in the next early spring. The second-year blade generally begins its growth with less breadth than the base of the first-year blade and so the

1) BÖRGESSEN: Note on the Question whether *A. esculenta* sheds its Lamina &c., p. 200.

demarcation between the two parts is never difficult to recognize. The illustrations of the Greenland specimens given by ROSENVENGE referred to above, point to this stage. As the remnant of the first-year blade is worn away as soon as the new blade has started, at least on our coasts, a favorable opportunity must be caught to observe the actual alternation of the blades. ROSENVENGE observed on the coast of Greenland that the lower part of the old blade of *A. grandifolia* J. AG. remained still unworn in summer.

BÖRGESSEN<sup>1)</sup> has discredited the observation by WILLE<sup>2)</sup> who writes, "dieses Endblatt fällt jeden Herbst ab und wächst von neuem heraus im Lauf des Winters." He confesses that he has "only seen specimens from April to August and from October to December:" and he fills up this gap with observation on the plant by Mr. R. RASMUSSEN, Director of the Faerøese High School. It is very much to be regretted that he had no winter specimens, indispensable forms for making a conclusive remark on the problem.

Granting the view of BÖRGESSEN as established from his observations on the Faerøese Islands and strengthened by RASMUSSEN's note, and as true for *Alaria* plants in the North Atlantic, the difference between his view and that of the others may be condensed to the question whether the renewal of the blades of *Alaria* is gradual or sudden. It will be wisest to answer the question thus:—"the renewal of the blades of *Alaria* may be gradual or sudden according to the conditions of the place where the plant grows." Still it is true that there is more evidence of sudden growth of the blade at a certain time of the year, than of the uniform speed of growth throughout the whole year.

I will here take this opportunity to relate briefly the life

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1) BÖRGESSEN: Mar. Algae of the Faerøes, p. 459.

2) WILLE: Beitr. zur Physiol. Anat. der Laminariaceen, p. 7.



history of Japanese species of *Laminaria* compared with that of *Alaria*. European botanists unanimously describe the annual sheddings of the blades of *Laminaria digitata*, *L. hyperborea*, *L. saccharina*, etc., some believing and some assuming the plants as perennial. As far as I could understand from the accounts of these three species, there seems to me no actual proof to warrant the assumption that their life-length is more than three whole years. It may live over two winters, but not three.

About 16 species of *Laminaria* are found on the coasts of Japan. Some of them are of great value for domestic use and export, and their life history and various other points have been closely studied. According to my own observations on *Laminaria japonica* ARESCH., *L. angustata* KJELLM., *L. ochotensis* MIYABE and *L. longissima* MIYABE, the discharge of spores from matured sori takes place, as a rule, between August–November. The sporelings, undoubtedly germinated from these spores, make their appearance during January–February of the next year. The first-year blade at its full length in July–September is known to the fishermen as “mizu-kombu” (water laminaria) on account of its soft and thin substance. It may or may not be soriferous at the end of the same autumn. Before the winter, the greater part of the blade is worn away and the entire frond practically ceases to develop further. In the early months of next year, the transition region is very active to form the second-year blade which is abruptly and considerably broader when compared with the first-year blade. The latter does not remain long upon the new blade, being only occasionally found by collectors. The second-year blade now increases in length with enormous speed, so quick in *L. longissima* as to elongate 70 feet or more in less than 5 months. In July–August the blade becomes soriferous and before the end of October



our coasts. It may give some help to understand what has been alluded to above.

### Economic Use of *Alaria*.

The economic value of *Alaria* plants can not be spoken of as great. In earlier times *A. esculenta* was eaten by the people of Scotland, Ireland, Iceland, Faeröese Islands and Denmark. TURNER writes in his *Historia Fucorum*, Vol. II, published in 1809:—“This plant is much eaten in Scotland; the parts employed for that purpose are the midrib, stripped of its membrane, which is extremely sweet, and the thick part of the pinnae, which are called *Keys*. These latter, however, are only brought to market when thick and fleshy, never when thin and membranous. It goes by the name of *Dabberlocks*. According to LIGHTFOOT its proper season is September; and he also observes, that it is recommended in the disorder called a *pica*, to strengthen the stomach and restore an appetite.” In *Algae Britannicae*, published in 1830, GREVILLE says:—“The midrib of this plant, when stripped of the membrane, and sometimes also the leaflets, are eaten in Ireland, Scotland, Iceland, Denmark, and the Faroe Islands. It is called in Scotland *Badderlocks* or *Henware* and in the Orkney Islands *Honeyware*. Dr. DRUMMOND informs me that in some parts of Ireland it bears the name of *Murlins*.” PRINTZ<sup>1)</sup> relates that *A. esculenta* and *Rhodymenia palmata* are two important food-algae in Iceland, where they are cooked in milk or water with flour or groats added to it. He speaks of the old Icelandic Saga in which these seaweeds are mentioned. In Iceland the plant is called *Bladtare* or *Butare*.

At the present time, the use of *A. esculenta* as food appears

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1) PRINTZ: Lidt om Tange, (Tidsskrift for vore Nyttvækster, 1908).

to have been abandoned in Europe, except in small localities. The Alaskan aborigines still appreciate, as I have been told from a Siwash chief, the matured sporophylls of *A. marginata* and other larger forms as a delicacy. I have seen the natives of Kamtschatka eat the midribs of *A. fistulosa*. This has been already noted by RUPRECHT in Tange des ochotischen Meeres, p. 355 (1848). He says:—"Nach WOSNESSENSKI ist sie (*A. fistulosa*) den Kamtschadalen (bei Javina), welche die Blattrippe essen, als « Kdusschisch » bekannt, *Ph. alatum* in derselben Gegend und in Petropawlowsk als « Kauam » oder « Kauan »: letztere wird gekocht ganz und mit verschiedenen Beigaben verspeist, die Blattrippe aber roh."

In Japan, where numerous species of seaweeds are used for food and other purposes, a considerable amount of *Alaria* is left unused. This is principally due to the fact that other brown algae, such as *Laminaria* and *Undaria*, much better in taste, consistency, etc., are found in association with it. The Ainu in the southern Kuriles frequently use the matured sporophylls as food.

As a source of kali or iodine, the *Alaria* plants are not entirely useless. The following table gives some of the analyses by TURRENTINE<sup>1)</sup> and by MIYAMA and KAKIHARA.<sup>2)</sup>

Species	Location	Potash (K <sub>2</sub> O)	Iodine (I)	Pot. Chlor. (KCl)
<i>A. valida</i>	San Juan County	9.2	0.08	14.5
<i>lanceolata</i> ?	Symonds Bay	3.0	0.12	4.7
<i>lanceolata</i>	Sitka	3.4	trace	5.4
<i>fistulosa</i>	Kuriles	11.53	0.010	—
sp.	Sakhalin	4.97	0.024	—
<i>praelonga</i>	Akkeshi	7.78	0.125	—
<i>praelonga</i>	Hamanaka	8.26	0.070	—

1) TURRENTINE: The composition of Kelps, p. 220.

2) MIYAMA and KAKIHARA: Reports on the Kali Resources, p. 18

Compared with other species of Laminariaceæ, the valuable contents, iodine and kali, are comparatively poor in *Alaria*. The kelp-burning of *Alaria* might pay fairly well only in such an extraordinary time as during this great war, when the market price of kalium chloride has become more than ten times as high as in ordinary days. The value of *Alaria* as a resource of kelp is much discounted by the fact that wherever *Alaria* plants grow, there are also found other Laminariaceous members which are richer in iodine and kali.

In short, *Alaria* plants have very little value as human food or for kelp-ash. For manure they may be used equally well as other brown seaweeds, such as *Sargassum*, *Fucus*, etc.

### Distribution and Habitat.

All species of *Alaria* are inhabitants of the northern colder seas. The greatest number of species are found within a range from about 42° N up to the arctic circle. On the Pacific coasts, its southern limit is at Kinkwasan Island (38° 17' N) on the west side (*A. crassifolia*) and about the middle part of California (37° N) on the east (*A. marginata*). On the west side of the Atlantic, no record of *Alaria* is known south of Cape Cod (about 41° 30' N) where *A. Pylaii* GREV. occurs; and on the east, *A. esculenta* GREV. finds its southern limit on the coast of France (about 45° N). In the Baltic Sea, *Alaria* is entirely wanting within the Kattegat.

In Japan, *Alaria* is found on the Pacific as well as on the Ochotsk coast. No species occurs in the Japan Sea. It may intrude into the Sea a short distance only through the two entrances, the Tsugaru Strait from the Pacific Ocean, and the Soya Strait from the Ochotsk Sea.



The absence of *Alaria* in the Baltic Sea and in the Japan Sea is not to be explained as parallel examples due to similar physical conditions. Within the Kattegat the salinity and temperature lower quickly towards the Baltic Sea. In the Japan Sea, on the contrary, both show higher figures than on the Pacific coast, as can be seen in the following tables.

I. Mean annual temperatures of sea-water at various parts of Hokkaido.

	Pacific coast			Tsugaru Strait		Japan Sea coast			
	Nosappu	Akkeshi	Erimo	Esan	Fukuyama	Inao	Suttsu	Kamui	Takashima
1911	6.6	5.9	5.6	10.3	13.8	12.9	11.8	11.1	11.6
1912	5.1	5.1	5.0	9.0	13.5	11.8	11.3	11.1	10.9
1913	4.4	4.6	6.4	8.1	12.4	10.7	10.5	9.5	10.2
1914	5.9	7.1	7.9	10.0	14.4	12.6	12.1	10.7	12.2
1915	5.4	6.0	7.1	9.8	13.9	12.2	11.3	10.2	11.8
1916	6.6	6.8	8.1	10.6	14.3	12.8	12.1	11.2	11.9

II. Mean annual density of sea-water at various parts of Hokkaido.

	Pacific coast			Tsugaru Strait		Japan Sea coast			
	Nosappu	Akkeshi	Erimo	Esan	Fukuyama	Inao	Suttsu	Kamui	Takashima
1911	1.0239	1.0236	1.0235	1.0244	1.0255	1.0251	—	1.0255	1.0251
1912	241	237	235	242	256	253	—	252	250
1913	241	238	239	243	256	251	—	248	246
1914	244	242	242	248	256	254	—	247	246
1915	244	243	234	245	255	252	—	245	247
1916	243	241	237	248	257	255	1.0249	249	252

In the above cited tables the localities are arranged from the eastern end of Hokkaido (Yesso Island) towards the west along the southern coast, then passing the Tsugaru Strait, towards the

north. Several species of *Alaria* are found about Nosappu, a few about Akkeshi and Erimo, and one about Esan. At Fukuyama, which stands at the western end of the strait or at the entrance of the Japan Sea, usually no *Alaria* is found. At the above mentioned places on the Japan Sea *Alaria* has never been collected.

Thus on the coast of Hokkaido where *Alaria* exists, the water temperature is never above 11° C, and where it is entirely absent the temperature is higher than that except in an unusually cold year. The salinity of water is generally less on the *Alaria*-existing coast than on the other. That the lesser density of the water is not an important factor for the existence of *Alaria* may be observed from the fact that Nosappu, where more *Alaria* in species and in number are found, has stronger salinity than the other two places. This view may be more emphatically expressed when we compare the Baltic and the North Sea.

The minimum temperature of seawater is much lower on the Pacific coast of Hokkaido than on the Japan Sea side. At Esan no record of water temperature below 0° C is known. At Erimo in December–February it goes below this point very frequently, and floating ice carried from the north-east is not infrequent there. On Feb. 26, 1915, -3.8° C has been recorded. On the coast farther north-east of Erimo the temperature is still lower in winter time and the shore is usually blockaded with a thick ice sheet during December–February. At Nosappu, on March 7, 1914, the water temperature near the surface went down as low as -11.0° C.

In the Baltic Sea the freezing of the seawater along the coast is general during winter.<sup>1)</sup> It may take place on the Swedish coast of the Kattegat. The Danish coasts and the open coasts of southern Norway which are washed by the Bank Water and the

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1) KYLIN: Studien über die Algenzora der Schwed. Westküste, p. 207.

North Sea Water<sup>1)</sup> respectively, are free from ice. From the data above stated we perceive that the physical conditions of the regions mentioned of the North Atlantic and of the North Pacific are just opposite in relation to the existence and non-existence of *Alaria*. This apparent contradiction, however, may be easily explained when we consider the origins of the waters of the Baltic Sea and the Japan Sea.

The Baltic Sea may be compared with, or regarded as, an extensive lake communicating with the Atlantic Ocean through the Skagerak and Kattegat. The Sea is supplied with freshwater from innumerable rivers. The ocean water known as the Jutland Current intrudes into the Sea along the Danish side of the straits. The mass of the intruding water is by no means large enough to have an influence upon the physical characters of the Sea. The water of the Sea is practically supplied by freshwater streams, the greater number of which originate in the colder regions. *Alaria*, which is an open-sea inhabitant, can never intrude into, or exist in, such a freshwater lake. Especially the Swedish side of the strait is washed by this *Alaria*-lacking water.

The Japan Sea has two main currents. The more influential one, known as the Tsushima Current, is a branch of the Japan Current and runs into the Sea through the Tsushima Strait, travelling towards the north-east along the west coast of Japan. Through the Tsugaru Strait a minor branch goes out into the Pacific Ocean close along the southern shore. The remaining part continues to proceed northward as far as the Soya Strait where it ramifies again into two parts, the major one bending eastwards through the strait and the minor one keeping the original course intruding into the Strait of Tartary.

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1) HJORT and GRAN: Hydrographic-Biological Investigations.

The other current, known as the Tartar Current, is less influential in comparison with the Tsushima Current. It has its origin at the Strait of Tartary and runs south-westwards along the continental shore. This stream has a lesser salinity and a colder temperature as may be easily understood from the fact that Vladivostock harbour is closed up by thick ice during winter while Otaru Harbour on the same latitude has never suffered from that trouble.

A certain amount of the water of the Pacific and of the Ochotsk Sea flows into the Sea along the northern sides of the Tsugaru Strait and the Soya Strait respectively. But these inflowings have little influence on the physical conditions of the Sea, compared with the influence of the Jutland Current along the Danish coast upon the Baltic Sea.

The Tsushima Current which supplies, as it were, the principal part of the water of the Japan Sea is a branch of the Japan Current. The latter has its origin in the north equatorial current and is tropical in its nature. As it travels north-eastward it deposits the spores of the tropical algae on the coasts of southern Japan and also carries the spores of the inhabitants of the latter further northwards. *Alaria* is neither a tropical nor a subtropical plant. The Japan Current and its branch carry, therefore, *Alaria*-lacking water into the Japan Sea.

The non-existence of *Alaria* in the Baltic Sea and the Japan Sea may now be easily explained. The two seas have no source from which *Alaria* may be carried in, and they are not birth-places of the plant.

*Alaria Pylaii* GREV. which is an inhabitant of the north-eastern coast of North America has been recorded, though with some doubt, from Spitzbergen. Thus the species may be taken

as a representative of the colder waters of the North Atlantic. Its occurrence in Puget Sound and the Alaskan coasts,<sup>1)</sup> detached and isolated localities for the distribution of the species, requires a careful revision. If it could be proved positively, the species would be the only one common to both the Atlantic and the Pacific Ocean.

Excepting the doubtful species above mentioned, each species has a more or less fixed area of distribution. Out of 15 species enumerated in this Monograph, 3 species are from the North Atlantic coasts and 12 from the Pacific. The Arctic Sea can by no means be said to have been thoroughly explored. Yet it is known that *A. grandifolia* J. AG. flourishes luxuriantly about Spitzbergen and *A. Pylaii* GREV. may very likely extend there. In the Siberian Sea, *A. dolichorhachis* KJELLM. is found, and this species is known to extend into the North Pacific through Bering Strait. From the Arctic coast of Alaska only one record of *Alaria* has been known. The record is based upon one of RATHROCK's sketches of algae determined by HARVEY as *A. esculenta*. In HARVEY's time the specific limitation of *A. esculenta* was much broader than at present, so the accuracy of the sketch is rather to be doubted. Yet it gives an evidence that certain species of *Alaria* exists on the Arctic coast of Alaska.

It is a noteworthy fact that many of the species of the North Pacific have very limited areas of distribution, while the North Atlantic species, though few in number, have much wider distribution. In the Pacific, *A. fistulosa* has the widest range of distribution, extending from the South Kuriles towards the north-west up to Dall Island. Several others are quite local in occurrence. A comparison of the distribution in the Atlantic and the Pacific is speci-

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1) Reported by SAUNDERS under *A. fragilis*.



ally interesting when we refer to the debate of BÖRGESSEN *v. s. v.* PORSILD and SIMMONS concerning the characters of the marine flora of the Faeröes. But there seems no need to reopen this discussion.

The following table is prepared after consulting the former records to show the distribution of the 15 species. The reader has to be cautioned that in the species of *Alaria* there are yet uncertain points regarding their exact limitations.

	North Atlantic			Arctic		E. coast of Asia.		W coast of N. Amer.	
	North Atlantic Islands	W. coast of Europe	E. coast of North America	Spitzbergen	Siberian Sea	Ochotsk Sea and Sakhalin	E. coast of Kamtschatka, Kuriles and N. Japan	Alaska to Vancouver Island	Vancouver Island to California
<i>A. esculenta</i>	+	+	+	....	....	....	....	....	....
<i>Pylaii</i>	+	....	+	+?	....	....	....	+	....
<i>grandifolia</i>	+?	....	....	+	....	....	....	....	....
<i>teniata</i>	....	....	....	....	....	....	+	....	....
<i>lanceolata</i>	....	....	....	....	....	....	+	....	....
<i>ochotensis</i>	....	....	....	....	....	+	....	....	....
<i>praelonga</i>	....	....	....	....	....	....	+	+	....
<i>macroptera</i>	....	....	....	....	....	+	+	....	....
<i>crassifolia</i>	....	....	....	....	....	....	+	....	....
<i>fistulosa</i>	....	....	....	....	....	+	+	+	....
<i>mini</i>	....	....	....	....	....	....	....	+	....
<i>ralila</i>	....	....	....	....	....	....	....	+	....
<i>marginata</i>	....	....	....	....	....	....	....	+	+
<i>angusta</i>	....	....	....	....	....	....	+	....	....
<i>dolichorhachis</i>	....	....	....	....	+	....	+	+	....

The observations on the nature of the Baltic Sea and the Japan Sea relating to *Alaria* lead us to think about the center of distribution of the genus. From the above table showing the distribution of the species, considered together with the nature of the currents which wash the localities, we are able to safely state that the localities are directly or indirectly washed by the Arctic waters.

We know very little of the algal floras of the Siberian Sea and the American Arctic Sea. How many species of *Alaria* may be found in the regions and in what state of growth they may flourish, is not satisfactorily reported. There are reasons, however, to assume that we may not expect many species from there. Yet the supposition that the north circumpolar regions might have been or may be the center of distribution of *Alaria* has some probability.

Starting from the above assumption I venture to say :—*Alaria* had its origin in the North Circumpolar Sea and migrated southwards into the Pacific and the Atlantic Oceans as far as where the Arctic currents terminate; the initial form gradually diverged into the various present species which flourish in a most vigorous state about the southern limits of the Arctic currents.

In general, the formation in which *Alaria* plants are habitually found is the sublittoral. They prefer the exposed coasts of steep rocks. Very frequently they form a narrow belt fringing the low water mark or within a few feet below it. Usually, however, they are associated with other algae, almost invariably with other Laminariaceous members, and may thrive to a depth of 4–5 fathoms below the low water mark.

The sporelings of *Alaria* germinate, except in the extreme north, in early spring. They are found in great abundance on rocks, mussels, larger algae, etc., immediately below the low water mark. A few months later, during the spring tide just following the vernal equinox, the water ebbs so as to expose these sporelings and young shoots to the strong heat of the sun. The majority are destroyed on this occasion, though many other plants adapted to such conditions may survive well. This is undoubtedly the cause why *Alaria* plants are found at a certain depth below the ordinary

low water level, the depth varying according to the tidal range of the locality.

Up in the north, the germinating season is undoubtedly later than in the south. The influence of the sun's heat upon the algae at low tide is not sufficiently intense to harm them. Here the plants may be found still flourishing, but not so well as in deeper water, just above the water level during the lowest spring tides. On the west coast of Vancouver Island, where the tidal range is as great as 25 feet at spring tides, the *Alaria* plants, as well as other Laminariaceous members, are exposed to the air at ebb-tide hours. This region is well known for the rich moisture in the air during summer, so that mist and fog prevail for several hours almost every day. The luxuriant growth of *Alaria*, which is properly a sublittoral inhabitant, between the tidal marks in this region is very likely due to this climatic circumstance. In the southern parts of Kamtschatka and in the North Kuriles, parallel examples might be met with.

BÖRGESSEN observes at the Faeröese Islands that *A. esculenta* is found as high as several feet above the lowest water mark at several places, as the dashing waves can irrigate the place. This is also the case with other places in the world and with some other species of algae. It is one of the ecological characters common to those algae which are inhabitants of the lowest littoral region and adapted to confront the surfs.

It is well known to the field algologists that *Alaria* plants are rarely found in quiet bays or in tide pools. An observation on the tide pool flora made by Miss SKINNER<sup>1)</sup> on the west coast of Vancouver Island is highly suggestive and may contribute a positive record for this fact. She studied eight tide pools of various

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1) SKINNER: Observ. on the Tide-pool Veget. of Port Renfrew, p. 153.

sizes and various heights above the low water mark, on a ridge of rocks which jutted into the sea sixty feet and was about thirty feet across its widest point. Pool No. I at the highest level was about 15 feet above the low water mark; and No. VIII at the lowest was nearly at the low water mark. No specimen of *Alaria* was found in the pools higher above the mark, and a few plants (species undetermined) were found "on the bottom in exposed position" of pool No. VIII. From the result obtained by her, and after consulting the floral features of the region, it is ascertained that *Alaria* plants can not properly exist in quiet places, however well it may be supplied with new water by constant irrigation. HARVEY<sup>1)</sup> remarked on *A. esculenta* :—"The roughest water seems to be most favourable to its existence." This is true for *Alaria* in general.

A few exceptional examples to the general statement above given, however, may also be mentioned. BÖRGESSEN<sup>2)</sup> observes on the Faeröese Islands that *A. Pylaii* seems to prefer somewhat sheltered coasts, and KJELLMAN<sup>3)</sup> also reports its occurrence in tide pools of the littoral formation in the Norwegian polar sea.

Describing the habitat of *A. grandifolia* J. AG., KJELLMAN<sup>4)</sup> says :—"The species is sublittoral, living generally at a depth of 2-15 fathoms. It is met with in the interior of deep bays as well as on exposed coasts, in the latter case near the shore, sometimes, when the bottom is favourable, several miles off. It is on rocky bottoms that it attains its greatest size. Living sometimes alone in rather great numbers, sometimes in accompany with other *Laminariaceæ*, it constitutes an essential element of the formation of *Laminariaceæ* on the coasts of Spitzbergen and the west coast

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1) HARVEY : Phyc. Brit., Plate 79.

2) BÖRGESSEN : Algae Vegetation of the Faeröese Islands, p. 754.

3) KJELLMAN : Algae of Arctic Sea, p. 215.

4) Ditto, p. 217.

of Novaya Zemlya." This description may be almost word for word applied to the habitat of *A. fistulosa* in the North Pacific. The fronds of enormous breadth and length reach the surface of the sea and then bend horizontally; the hollow midrib serves as a buoy and the blade hangs down along it like a gigantic *Musa* leaf. A large number of the plant are usually found aggregated at some distance from the sea shore, choosing a suitable depth and substratum for growth. In the South Kuriles the favourable site is in waters of 5–7 fathoms depth and in the North Kuriles, a little shallower. It is told by seal hunters that the dense aggregation of the floating blades is a resting place for the sea-otters. According to SETCHELL and GARDNER,<sup>1)</sup> its habitat on the coasts of north-western Alaska seems to be about the same. KJELLMAN<sup>2)</sup> simply remarks that it is gregarious in the lower part of the sublittoral region of the Bering Islands.

The two examples mentioned above tell us the fact that the spores of these species germinate in a much deeper place than the others. This does not mean, however, that they choose a calm place for their existence. They are found, at least *A. fistulosa* as I have actually observed, in those places where the currents are unusually swift. Their anchorage in deeper water may be more probably an adaptation for their enormous length of frond, in analogy to *Nereocystis* or *Macrocystis*.

### Systematic Position of the Genus *Alaria*.

The genus *Alaria* in the sense taken by modern algologists was established by GREVILLE in 1830 for *Fucus esculentus* L. Prior to this, the plant was mentioned, though not very precisely, under

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1) SETCHELL and GARDNER: *Algae of N. W. North Amer.*, p. 276.

2) KJELLMAN: *Om Beringhafvets Algflora*, p. 41.



*Ceramium* by STACKHOUSE in 1801, under *Muscefolia* by the same author in 1809, under *Laminaria* by LAMOUROUX in 1813, under *Orgyia* by STACKHOUSE in 1816 and under *Phasganon* by GRAY in 1821. RUPRECHT has given a lengthy discussion on the priority of the generic name for the plant in his *Tange des ochotischen Meeres*, p. 365, and he preferred the name *Phasganon* to others. GOBI in *Die Algenflora des Weissen Meeres*, p. 77, revived the *Orgyia* instead of *Alaria* and *Phasganon*.

Whatever the historical records of the plant may be, the name *Alaria* as a genus under Laminariaceae is at present so widely adopted that any alteration would result but in confusion.

Which species of *Alaria* was first known to science, is also a much debated question. In current references *Fucus esculentus* in LINNÉ'S *Mantissa* published in 1767 is mentioned to have been the first. RUPRECHT published the view that *Fucus alatus* described by CARGILL in 1720 is undoubtedly the plant that LINNÉ meant by *Fucus esculentus*, and should stand in place of it. He also points out that *Fucus pinnatus* GUNNER (1766) and *Fucus teres* GOOD. et WOODW. (1797) are to be synonymized under it. In his *Tange des ochotischen Meeres*, therefore, the name *Phasganon alatum* is adopted in stead of *Alaria esculenta*. GOBI mentioned *Orgyia pinnata* as a more legal name than these two. Researches of old literature and strict hold of the rule of priority might lead to the view of RUPRECHT or GOBI. The specific, as well as the generic names adopted by these two writers, however, are pre-Linnean and simply historical.

The thorough classification of Laminariaceae we owe to SETCHELL'S work published some twenty five years ago. He arranged the then known 19 genera of the family into tribes and subtribes according to the probable affinities, mainly based upon

the morphological characters. Since that time there have been added numerous species and genera to the family, counting today 29 genera including a few questionable or critical ones. Extended observations on the anatomy and the development of the frond have thrown much light on the family. SETCHELL's classification requires, therefore, additions and amendments on various points. REINKE's Studien zur vergleichenden Entwicklungsgeschichte der Laminariaceen, though a highly interesting and instructive paper, does not add much in this line to SETCHELL's view. According to SETCHELL, and adopted by REINKE, *Alaria* is most closely related to *Pterygophora* so that he has established for these two the subtribe Alariæ under the tribe Alariideæ. Both are indeed sharply distinguished from all other co-families by having the sori on the leaflets situated upon the stipe alone.

Under the same tribe SETCHELL included *Undaria*, *Ecklonia* and *Eisenia* group, under the subtribe Eckloniæ. This classification is undoubtedly derived from his incomplete acquaintance of *Undaria* at that time, as he complained of the difficulty of getting its material for study. He also put too much stress on the marginal outgrowths from the blade of *Eisenia*.<sup>1)</sup> Recent observations on *Undaria* by OKAMURA and by the present writer give ample evidence that it has less affinity with *Ecklonia* or *Eisenia*, while on the contrary, the genus has a very close relationship with *Alaria*.

The sori of *Undaria* develop on the wing-like outgrowths on both edges of the stipe and nowhere else. These outgrowths are practically enormous extensions of the edges. The ruffle-like undulations of the external margins result from the excessive growth in length in the marginal parts. These undulated sporophylls, as they are called, are at some distance below the transition region in

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1) SETCHELL: Post-Embryonal Stages of Laminariaceæ, p. 129.

f. *distans* MIX. et OKAM., quite approximate in f. *typica* YENDO and confluent with in f. *narutensis* YENDO. Whatever the gradations may be in the separation of the sporophylls from the sterile blade, the essential difference between the sporophylls of *Alaria* and *Undaria* is in the degree of their differentiation. In the former they are separated into a number of petiolated leaflets<sup>1)</sup> while in the latter they are continuous and directly confluent with the stipe edges. *Hirome undarioides* YENDO shows a step more primitive in this respect than *Undaria*.

*Alaria*, *Undaria* and *Hirome* have the true midrib. There are costated members among the family Laminariaceæ, such as *Agarum*, which, however, must by no means be regarded as standing near to them. *Pterygophora*, which is acknowledged to have the closest relationship with *Alaria*, is not provided with the true midrib. Yet its presence in the three named genera must never be passed over as merely incidental.

The mucilage glands, again, as far as has hitherto been observed, are limited to *Alaria*, *Undaria*, *Hirome*, and *Laminaria Peterseniana* KJELLM. The last mentioned species has neither midrib nor sporophylls. On the other hand, it has various peculiarities to be counted under the genus *Laminaria*. OKAMURA's idea to comprise it in *Undaria* together with *Hirome* is hardly acceptable before we have extended the limitations of the other genera of Laminariaceæ.

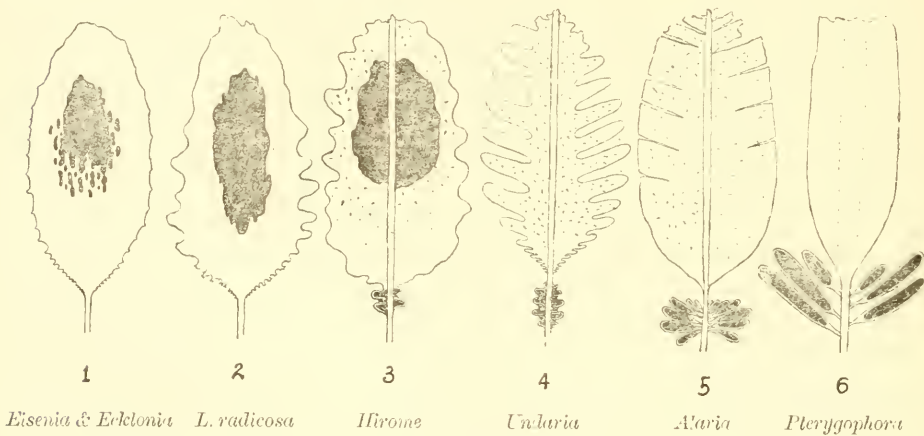
Leaving *L. Peterseniana* KJELLM. aside for the present, the three genera, *Alaria*, *Undaria* and *Hirome*, form a continuous series, and the genus *Pterygophora* stands near *Alaria* in another direction.

SETCHELL<sup>2)</sup> holds the view that "the nature of the outgrowths

1) There are various degrees in separation of the leaflets; compare *A. Pylaii* (Pl. VII, fig. 1) with *A. macroptera* (Pl. II, fig. 1), and *A. angusta* (Pl. XV, fig. 1).

2) SETCHELL: Post-Embryonal Stages of Laminariaceæ, p. 126.

from the blade of *Eisenia* are certainly most important" in generic consideration of the Laminariaceæ. Upon this ground *Eisenia*, *Ecklonia* and *Undaria* are associated in the subtribe Eckloniæ under the tribe Alariidæ. If so, the marginal outgrowths of *Eisenia* and *Ecklonia* must be first compared with those of *Laminaria radicata* KJELLM. The latter species shows in several points a certain affinity with *Hirome* and *Undaria*, and more indirectly with *L. Peterseniana* KJELLM. The relationship between *Eisenia* and *Alaria*, if any, should be considered as most indirect, placing *Laminaria radicata*, *Hirome*, and *Undaria* between them.



A series of diagrammatic figures to show the varieties of localization of sori  
in various genera of Laminariaceæ.

### Synoptical Key to the Species.

1. Matured sporophylls entirely soriferous ..... I. Holosoria.
  - A. Midrib interruptedly hollow.....*A. fistulosa* P. et R.
  - B. Midrib thoroughly solid.
    - a Blade finely corrugated in the upper part.
    - Sporophylls dropped with petioles...*A. macroptera* (RUPR.)

- Sporophylls dropped leaving petioles
  - on the stipe ..... *A. ochotensis*.
- β. Blade smooth in the upper part.
  - Sporophylls linear ..... *A. praelonga* KJELLM.
  - Sporophylls cuneate ..... *A. dolichorhachis* KJELLM.
- γ. Blade finely striated in the upper
  - part ..... *A. marginata* P. et R.
- 2. Matured sporophylls bearing foliose
  - sterile portions at the apices.....II. *Metasoria*.
- A. Sporophylls pinnate.
  - α. Sporophylls disposed at great inter-
    - vals ..... *A. Pylaii* GREV.
  - β. Sporophylls disposed at regular
    - intervals, except the lower ones.
    - Sporophylls very thick, almost
      - terete .... *A. crassifolia* KJELLM.
    - Sporophylls coriaceous with cuneate
      - bases..... *A. esculenta* GREV.
    - Sporophylls coriaceous, large, with
      - obtuse bases..... *A. valida* SETCH. et KJELLM.
  - γ. Sporophylls very much approximate.
    - Sporophylls obliquely ascending.... *A. nana* SCHRADER.
    - Sporophylls patent ..... *A. grandifolia* J. AG.
- B. Sporophylls fasciculate.
  - α. Rhizines cylindrical ..... *A. lanceolata* KJELLM.
  - β. Rhizines complanated and thick.
    - Sporophylls cuneate, soriferous part
      - broader than the sterile crown.. *A. teniata* KJELLM.
    - Sporophylls long cuneate ..... *A. angusta* KJELLM.



## SPECIES.

*Alaria fistulosa* P. et R.

(Plate I, figs. 1-4.)

Illustr. Alg., p. 11, Tab. XVI.—J. AG.: Spec., I, p. 144.—KÜTZ.: Spec. Alg., p. 579.—KJELLMAN: Om Beringhafv., p. 49.—SAUNDERS: Harr. Alaska Exped., Algae, p. 426, Pl. LVII.—SETCH. et GARDN.: Algae N. W. N. Amer., p. 276.—COLLINS, HOLDEN and SETCH.: Phyc. Bor.-Amer., Fasc. B. No. XLII.—KIBBE: in Puget Sound Mar. Station Publ., Vol. I, p. 43, fig. 1-33.

= *Phasganon fistulosum* RUPR.: Tange des och. Meeres, p. 355 *et f.*

?= *Alaria marginata*  $\beta$  *musiformis* P. et R.: Illustr. Alg. p. 11.

?= *Alaria* sp? KJELLMAN: Om Beringhafv., p. 42.

*Definition of the species.* Root, at an early stage of development, holdfast of dendritic ramification, soon issuing numerous, branching, filiform rhizines successively above, the new rhizines growing over and interweaving with the older ones, resulting in general outline to a high conical mass. Blade linear, 10-25 meters in length, 30-90 cm. in breadth, membranaceous and brittle, densely glandulated, cryptostomata wanting, coarsely transversely corrugated along the midrib, margin entire, undulating, splitting transversely to the midrib in the older part; base of blade gradually tapering, tip of blade .... Stipe 20-50 cm. in length, terete and verruculose below, 8-12 mm. in diameter, gradually complanated and slightly broadened above, measuring 10-20 mm. in width, narrowed at the transition point; lower half of the length naked, upper half to the narrowed region bearing the sporophylls. Midrib 2-3 cm. broad, elevated above the blade on both surfaces with sharp edges, the middle one-third of the breadth longitudinally inflated, showing an elliptical cross section, but septated at irregular intervals, canaliculated along both sides of the inflation; these peculiarities disappearing before reaching to the transition point

where the midrib continues to the stipe below. Sporophylls holosoric, numerous, compactly disposed on both sides of the stipe, adding new ones successively above, oblong-obovate, or elliptical, 12–20 cm. in length, 2–4 cm. in breadth, cartilaginous, with well-defined cylindrical petioles; base of sporophyll obtuse or round, generally asymmetrical, tip round. Sorus on both surfaces of each sporophyll, in a continuous patch, occupying the whole surface leaving but a narrow border along the margin sterile.

*Remarks on the species.* This is a very distinct and well marked species. The much interwoven, tall conical or mitriform holdfast and the hollow but septated midrib are unrivalled characters among the allies. The sporophylls are ovate-spatulate, considerable in number, and densely beset in a limited portion of the stipe. At the beginning of appearance, they are membranaceous and obovate, very densely disposed on the margins of the stipe, *i. e.*, in a manner quite different from other species. The blade may often attain more than 50 feet in length, 3 feet in breadth, decussately cleft like a *Musa* leaf. It is the largest form of *Alaria*.

The plant grows gregariously at a depth of 5–10 fathoms below the low water mark. The upper parts of the blades, when the tide is low, float on the surface of the water and afford a resting buoy for sea-otters and other marine fur-animals.

SETCHELL and GARDNER distinguished two formæ, f. *platyphylla* and f. *stenophylla*, from the Unalaskan forms. But judging from the descriptions and considering the Kurile specimens, the formæ proposed seem merely due to the state of growth, as has been already observed by KIBBE.<sup>1)</sup>

The specimen kept in the herbarium of the Botanical Museum

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1) KIBBE: Puget Sound Mar. Station Publ., Vol. I, p. 43.

of Upsala under *Alaria* sp?, undoubtedly the plant mentioned in Beringhafv., p. 42, appears to me to be a fragment of an abnormal blade of *A. fistulosa*, although the characteristic hollow midrib could not be ascertained in the specimen.

In Illustr. Alg., p. 11, POSTELS and RUPRECHT mention *A. marginata*  $\beta$  *musæformis*. The brief description of this forma does not give any concrete idea of a distinct form of the plant. The original, kept in the herbarium of the Academy of Science of Petrograd, is a poor specimen without sporophylls. SETCHELL<sup>1)</sup> notes that he recognized in the midrib an "evident symptom of having been characteristically and interruptedly fistulose."

KJELLMAN<sup>2)</sup> remarks on the present species: "Arten synes mig vera närmest beslägtad med *A. tæniata*. Kostans grundform är densamma." I am rather astonished to read this statement. In the herbarium of the Botanical Museum of Upsala there is a young specimen of *A. crassifolia* KJELLM. determined by KJELLMAN as *A. fistulosa*. The above statement together with this identification make me doubt the specific conception of *A. fistulosa* held by KJELLMAN.

In the remark appendiced to the note on *Orgyia pinnata*, GOBI mentions a specimen with hollow and septated midrib in the Herbarium of the Botanical Museum of the University of Petrograd. The specimen, according to him, is from POSTELS and has been collected in a northern sea without exact locality. I have not seen the specimen in the Herbarium. But it appears to me very likely that it might have been collected in the North Pacific and should be identified with *A. fistulosa*. GOBI was tempted to neglect the peculiarity of the midrib, saying:—"Ich führe dieses Beispiel

1) SETCHELL: Critical Notes on Laminariaceæ, p. 11.

2) KJELLMAN: Beringhafv. Algflora, p. 42.

an nur um zu zeigen, dass die Aufblähung der Rippe oder Stiel—was eigentlich dasselbe ist—keinen irgend welchen specifischen Werth erhalten kann." It is to be regretted that he has not seen the specimens of the North Pacific *Alaria* in the Herbarium of the Academy of Science of Petrograd.

*Locality.* Augustine Bay, Dall Island (FRYE); Wrangell Narrows (SAUNDERS, SETCHELL and GARDNER); Douglas (JEUNE, SETCHELL); Juneau (SAUNDERS); Glacier Bay (SAUNDERS); Yakutat Bay (SAUNDERS); Prince William Sound (SAUNDERS); Cook's Inlet (SAUNDERS, RIGG); Kukak Bay (SAUNDERS); Kadiak Island (POSTELS and RUPRECHT, SAUNDERS, SETCHELL); Bay of Unalaska (POSTELS and RUPRECHT, SETCHELL); Kyska Island (TOWNSEND and SETCHELL); Bering Island (KJELLMAN); Kurile Islands(!); Kushiro, Yesso (MIYABE)(!); Kitami Prov., Yesso (MIYABE); Sakhalin (Herb. A.C.S.\*).

*Alaria macroptera* (RUPR.) nov. nom.

(Plate II, figs. 1-5.)

- = *Phasganon macropteron* RUPR.: Tange des oeh. Meeres, p. 353.
- = *Alaria macrophylla* MIYABE: Lam. of Hokkaido, p. 56, Pl. 25.
- = *Alaria corrugata* MIYABE: Lam. of Hokkaido, p. 55, Pl. 24.
- = *Alaria esculenta latifolia* P. et R.: Ill. Alg. p. 11. Pl. XVII.
- = *Alaria esculenta pinnatifida* P. et R.: Ill. Alg. p. 11. p.p.
- = *Alaria marginata* P. et R.? in Herb. Acad. Petropol.
- ? = *Alaria laticosta* SAUNDERS (non KJELLM.): Harr. Alaska Exped. Algae, p. 425, Pl. LV.
- = *Phasganon alatum* var. *latifolium* RUPR.: in Herb. Acad. Petropol. p.p.
- = *Phasganon longipes* RUPR.: Tange des oeh. Meeres, p. 353.

*Definition of the species.* Root, holdfast of dendritic ramification; blade linear lanceolate, 3.0-4.5 meters in length, 25-30 cm.

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\* Agricultural College, Hokkaido Imperial University, Sapporo.

in width at the broadest part, membranaceous, richly transversely corrugated, cryptostomata wanting, margin finely crisped, splitting in the older parts transversely to the midrib; base of blade gently tapering or acute when young, roundish or even cordate when old, tip of blade narrowed above, pinnately split and usually worn away. Stipe 5–12 cm. in length, cylindrical below in well developed and matured specimens, 4–6 mm. in diameter, terete and more or less broadened above, narrowed below the transition point, lower half of the length naked, upper terete part bearing the sporophylls, but in the younger individuals subcompressed or ancapitous till almost to the base, and bearing sporophylls from near the base. Midrib complanated, 6–10 mm. broad, elevated above the blade equally on both surfaces with round edges, continuous with the stipe below. Sporophylls holosoric, 30–40 in number, pinnately arranged on both margins of the terete part of the stipe, a few lowermost ones more or less apart, but the middle and upper ones close together, with the bases of the petioles fused into a continuous narrow wing on each margin of the stipe, lanceolate or linear-cuneate, 20–30 cm. long, 3.0–4.5 cm. wide in the broadest part; base of sporophyll acute, often obtuse, very frequently oblique, ending in a cylindrical petiole; tip obtuse with rounded apex, or often round. Sorus in a continuous patch on both surfaces of each sporophyll, occupying generally the entire area of the surface except a narrow border along the margin, but frequently leaving an upper part sterile and membranaceous.

*Remarks on the limit of variation.* The present species attracts the attention of the collector by its finely corrugated and very long blade. This character, however, is often not remarkable in some individuals, especially in the lower half of the length. In a herbarium specimen, when the upper portion has been cut off,



this important peculiarity is not recognizable. The shape of the base of the blade is also variable as in many others, according to the age of frond. In the young forms it is cuneate or acute, but in the fully matured forms, rounded or even cordate, with the transition point acute for a short length. The close arrangement of the sporophylls also varies somewhat, being sometimes, especially in the younger forms, more or less separated. The plant, therefore, seems to have a tendency to approach *A. praelonga* KJELLM.

The type specimen in the Herbarium of the Academy of Science of Petrograd has the sporophylls only partly soriferous. The upper sterile portion of each is thin and membranaceous, broader than the soriferous portion. This character suggests the placing of the species under the Metasoria. But after consulting the numerous specimens from our coast, which can not but be identified with the present species, I am strongly inclined to dispose the species under the Holosoria. In some specimens, the sporophylls are oblong linear, with both ends obtuse or rounded, and in others very long linear, often measuring more than a foot in length and only a few centimeters in breadth.

*Remarks on the synonyms.* The present species is easily recognized and distinguished from the others by having a finely plicated blade and large sporophylls. RUPRECHT has already observed the former character as he states "Querfalten am Blatte ausgezeichnet, selbst am Rande der Fiedern."<sup>1)</sup> The plication of the margins of sporophylls, however, is due to unequal contraction of the soriferous and sterile areas in drying. In the fresh specimens they are simply undulating. The broad base of the blade is counted by RUPRECHT as one of the specific characters. This has been regarded as of specific importance by MIYABE, SAUNDERS,

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1) RUPRECHT: *Tafel des ocher. Meeres*, p. 354.

KJELLMAN, etc., in describing their species listed above. The shape of the base of the blade, however, is of secondary importance. RUPRECHT himself relates on *Phasganon longipes* RUPR.:—"Ein Rasen mit 5 Exemplaren von der S. W. Küste von Kamtschatka bei Javina im September gesammelt, erhielt Blätter mit mehr oder weniger deutlich eiförmiger Basis und ein Blatt, dessen unteres Ende in den Stamm ausgezeichnet keilförmig und lang gezogen war: hier konnten nicht zwei Arten gemischt sein, denn all übrigen Character war dieselben." We have in our herbarium many specimens showing such variations as RUPRECHT had noticed.

Having examined and carefully studied the original specimens of *Phasganon macropterum* RUPR. and *Phas. longipes* RUPR. in the herbarium of the Academy of Sciences of Petrograd, I have not the least doubt of the propriety of combining them into one species. RUPRECHT seems to have laid too much stress on the length of the stipe, which is never a matter of specific importance but one generally due to the habitat. A glance at the original specimen of *Phas. macropterum* gave me the conviction that *A. corrugata* MIYABE, which is quite familiar to me, is another form which should be amalgamated with that species.

SAUNDERS identified a specimen from Kukak Bay with *A. laticosta* KJELLM. in spite of what KJELLMAN has said of the specimen: "the form, color and consistency of the blade, and the form, width and rigidity of the sporophyll differ somewhat from this species." These characters which KJELLMAN mentioned are all important specific ones, and yet SAUNDERS did identify his plant with KJELLMAN's species. It might have been because of the broadness of the midrib of his specimen. As may be understood from what is stated on p. 20 of the present paper, the breadth of the midrib is variable and hardly of systematic value. The illustration of

SAUNDERS' specimen delineated by himself (l. c., Pl. LV) may be referred to either the present or *A. ochotensis*. His description for his plant is so brief that I am unable at present to reach a concrete decision. But the fine corrugation of the blade, so excellently delineated by him, justifies the referring of the plant to this species. The fact that in his plant the scars of the dropped sporophylls are found on both sides of the stipe till near the hold-fast, point at the same time to the next species.

In Grönland Lam. och Fuc., J. AGARDH doubts *Phas. longipes* RUPR. to be equivalent with his *A. grandifolia*. On examining the original of the latter at Lund, I can not agree with J. AGARDH's view about the identity of these two species.

J. AGARDH seems to have regarded *Phas. macropterum* RUPR. as comparable with *Laminaria Pylaii* DE LA PYL. Cfr. Spetzbergens Alger, p. 30. However RUPRECHT's species may cover more than one form of plant, no specimen referable to *A. Pylaii* is to be found among the originals of *Phas. macropterum* in the herbarium of the Academy of Science of Petrograd.

The name *Phas. alatum* RUPR. var. *latifolium* RUPR. has practically the same limitation as *A. esculenta latifolium* P. et R. After careful study of the original specimens in Petrograd, the plants under this name are quite inseparable from those under *Phas. alatum macropterum* RUPR. and comprise *A. Pylaii* GREV., *A. praelonga* KJELLM. and *A. macroptera* in the sense taken in the present paper.

A specimen from Petropaulowsk, Kamtschatka, bearing in RUPRECHT's own handwriting the note: "*Alaria marginata* P. R. ? est potius *A. esculenta* var. *latifolia* Ill. Alg." is in the herbarium of the Academy of Sciences of Petrograd. This is to be referred to the present species.

*Locality.* Kurile Islands (Herb. S. A. C.); Port Ochotsk

(RUPRECHT); Ajan Bay (RUPRECHT); Petropaulowsk, Kamtschatka (LÜTKE, POSTELS and RUPRECHT); ?Kukak Bay (SAUNDERS, under *A. laticosta*); Tonnaicha, Sakhalin(!).

*Alaria ochotensis* sp. nov.

(Plate III, figs. 1-5; Plate XIX, figs. 1-3.)

*Definition of the species.* Root, holdfast of dendritic ramification, with filiform rhizines. Blade linear-lanceolate, more than 2.5 meters in length, 25-30 cm. in width at the broadest part, membranaceous, extremely thin when dried, finely transversely corrugated in the matured forms, frosted with numerous cryptostomata; margin entire, undulated or crisped, splitting in the older parts transversely to the midrib; base of blade acute from an early stage of development, tip of blade narrowed above, pinnately split and usually worn away. In the cortical layer of the blade, peculiar, ramified glandular cells present, the content of which turns brownish on drying, giving the blade a characteristic brown colour. Stipe short, 3-4 cm. in length, terete or cylindrical below, gradually broadened and complanated above, narrowed again at the transition point, naked for a short length near the base, bearing sporophylls on the margins of the complanated part. Midrib complanated, with slanting edges, 0.7-1.3 cm. broad, elevated above the blade equally on both surfaces, continuous with the stipe below. Sporophylls, holosoric, 30-40 in number, pinnately arranged on both margins of the complanated part of the stipe, a few lowermost ones more or less independent, but middle and upper ones starting from a narrow continuous wing on each margin of the stipe, adding new ones successively upwards, lanceolate or linear-cuneate, 10-15 cm. long, 2.0-2.5 cm. wide in the broadest part; base of sporophylls acute, often obtuse, very often oblique, ending in a

cylindrical petiole which is persistent on the stipe after the sporophyll has dropped; tip obtuse or rounded. Sorus in a continuous patch on both surfaces of each sporophyll, occupying generally the entire area of the surface, except a very narrow border along the margin, but frequently leaving the upper part sterile and membranaceous.

*Remarks on the affinity of the species.* The present plant has some resemblance to *A. dolichorhachis* KJELLM. and *A. lanceolata* KJELLM. But it may be readily separated from them by having extremely thin, membranaceous, corrugated blade as well as a peculiar kind of glandular cells. In general appearance of frond, it stands most closely to *A. macroptera*, so that I was rather uncertain if it would not be better mentioned under its varietal rank. From that species, however, it may be distinguished by rich cryptostomata and glandular cells in the blade, by non-approximate sporophylls, and by the petioles of the dropped sporophylls remaining attached to the stipe.

The form conception of *A. esculenta pinnatifida* P. et R. taken by the authors is rather difficult to understand. The definition given in Ill. Alg., p. 11 is well applicable to this species. But as far as I could understand from the original in the herbarium of the Academy of Science of Petrograd, as determined and arranged by RUPRECHT, there appear more than two distinct forms under the formic name. One of them, collected in Kamtschatka, has certain resemblance to *A. Pylaii*. The others approach to either *A. macroptera* or the present.

As remarked under the preceeding species, the plant which SAUNDERS has identified with *A. laticosta* KJELLM. seems to have certain points comparable with this species.

*Locality.* Southern part of Sakhalin (K. MIYABE, Herb. S. A. C.); Aniwa Bay, Sakhalin (S. MURATA) (!).



*Alaria praelonga* KJELLM.

(Plate IV, figs. 1-5.)

Om Beringhafv. Algfl., p. 38, Tab. 4, fig. 1-4. — DE TONI: Syll. Alg. III, p. 330.

= *Phasganon alatum* RUPR.: Tange och. Meer., p. 355, 359. *p.p.*

= *Phasganon alatum* var. *latifolium* RUPR.: Ditto, p. 355, *p.p.*

= *Alaria esculenta* P. et R.: Ill. Alg., p. 11, *p.p.*

= *Alaria yessoensis* MIYABE: Lamin. of Hokkaido, p. 54, Pl. 23.

? = *Alaria lanceolata* COLL., HOLDEN et SETCH.: Phyc. Bor.-Amer. Fasc. B. No. XLIV.

*Definition of the species.* Root, holdfast of dendritic ramification. Blade linear, 1-7 meters, generally 2-3 meters in length, 10-13 cm. in breadth, coriaceous, cryptostomata wanting, margin entire, splitting obliquely to the midrib in the older parts; base of blade gently tapering; tip narrowed above, pinnately cleft and generally roughly worn away. Stipe 3-12 cm. in length, subcylindrical below, 2.5-3.0 mm. in diameter, gradually compressed above, measuring 3-5 mm. in width, but quickly narrowed at the transition point; lower half of the length naked, upper and compressed part, except the narrowed region, bearing sporophylls. Midrib smooth, complanated, 5-13 mm. broad, elevated above the blade on both surfaces with roundish edges, continuous with the stipe below. Sporophylls, holoserice, 12-40 or often more in number, pinnately arranged on both margins of the complanated part of the stipe, a few lowermost ones at wide intervals, but middle and upper ones approximate and regularly disposed, adding new ones successively upwards, linear-oblong or linear, 6-20-30 cm. in length, 1.5-2.5 cm. in breadth, with well defined cylindrical petioles; base of sporophyll obtuse, very frequently asymmetrical; tip roundish or obtuse. Sorus on both surfaces of each sporophyll,

generally occupying the entire surface except a narrow border along the margin.

*Remarks on the limit of variation.* Although the shape of the base of the blade of most members of the Laminariaceæ varies according to the stage of development of the plant, the gradual attenuation, *e.g.*, narrow cuneate shape in the present species is quite constant and remarkable. The substance of the blade is coriaceous, resembling a thick parchment paper on drying. A remarkable character of the present species is that the blade is entirely wanting in cryptostomata as far as I could determine.

Some specimens may have numerous small holes in the upper and older part of the blade, often so numerous that the part gains the appearance of a cribrous lamina. These perforations become smaller in size and less in number as we trace them downwards and finally they may be reduced into mere brownish spots, very sparingly distributed on the blade. Under the microscope, these brownish spots show shallow depressions of the cortical part on either surface with a much distorted arrangement of the cortical cells. I was not able to find any reason for calling the depression a cryptostoma or hair-pit. The specimens from Hidaka Province, however, have had sparing cryptostomata showing with other specific characters an intermediate form between the typical forms of both *A. praelonga* and *A. crassifolia*.

A typical form of the present species has the sporophylls arranged at regular intervals as in *A. esculenta* and *A. crassifolia*. The shape of the sporophyll is linear, with a round or obtuse apex and an obtuse, very frequently asymmetrical, base. As already mentioned before, we sometime meet with an intermediate form in the characters of sporophylls between the present and *A. crassifolia*. In such case, the presence or absence of cryptostomata

and the shape of the base of the blade may be taken as the discriminating characters.

*Remarks on the synonyms.* Among the specimens under *Phas. alatum* var. *latifolium* RUPR., preserved in the Academy of Science of Petrograd, there are some from Javina, Kamtschatka. These differ greatly from the rest by having leather-like blades and much aggregated sporophylls. Judging from RUPRECHT's handwriting on the specimen sheet, he seems to have had ample doubt on the determination and to have at first supposed them to be a young stage of *Phas. marginatum* RUPR. But I am inclined to consider them to be referable to the present species. The Petropaulowsk specimen of *A. esculenta* P. et R. as treated in *Illustr. Alg.*, p. 11, also seems to be joined here.

The plant distributed as *Phye. Bor.-Amer.*, Fasc. B., No. XLIV, was at first hesitatingly identified with *A. lanceolata* by SETCHELL. He<sup>1)</sup> referred it later to *A. marginata* P. et R. The specimen in the copy I have seen was provided with comparatively few sporophylls set apart at regular intervals in the main part, some younger ones being aggregated at the upper. The shape and substance of the sporophylls, as well as the arrangement on the stipe, recalled more of *A. praelonga* KJELLM. than any other species. It is to be questioned how SETCHELL comprehended *A. praelonga* KJELLM. The informations concerning this species in *Algae of the Pribilof Island*, p. 529 and in *Algae of the Northwestern Coast of North America*, p. 274, are therefore not referred to here.

*Locality.* Javina, Kamtschatka (RUPRECHT); Petropaulowsk, Kamtschatka (POSTELS and RUPRECHT); Bering Islands (KJELLMAN); South-eastern coast of Hokkaido, Japan (Herb. S. A. C.).

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1) SETCHELL: *Critical Notes on Laminariaceæ*, p. 11.

*Alaria dolichorhachis* KJELLM.

(Plate V.)

Algae of Arct. Sea, p. 27, Pl. 20-21, 25, fig. 11-18.—Id.: Beringhafv. Algfl., p. 35.—DE TONI: Syll. Alg. III, p. 328.—SETC. et GARD.: Alg. N. W. Amer. p. 272.

= *Alaria elliptica* KJELLM.: Alg. Arct. Sea, p. 221, Pl. 23, Pl. 25, fig. 25, 26.—DE TONI: Syll. Alg. III, p. 329.

= *Alaria crispa* KJELLM.: Beringhafv. Algfl., p. 37, Tab. 3, fig. 5-7.—DE TONI: Syll. Alg. III, p. 330.

= *Alaria muscfolia* J. AG. in litt. Herb. J. AGARDH. (tantum specimen Spitzbergensis).

= *Alaria Pylaii* J. AG.: Bidrag till Kännedom Spetzberg. Alger, p. 30 (non alior).

? = *Alaria esculenta* HARV.: Flora West Esk., p. 49 (see. KJELLMAN).

? = *Alaria esculenta* var. *latifolia* f. *singularis* RUPR. (Herb. Acad. Petropol.).

*Definition of the species.* Root, holdfast of dendritic ramification. Blade ovate-lanceolate, 1 meter or less in length, up to 40 cm. in width at the broadest part, thin, membranaceous, cryptostomata wanting; base of blade cuneate for a short length, abruptly expanding upwards into a broad roundish shape. Stipe up to 20 cm. in length, cylindrical below, 3-4 mm. in diameter, terete and broadened above, narrowed below the transition point. Midrib smooth, 4-7 mm. broad, prominent with roundish edges. Sporophylls, holosoric?, numerous, pinnately arranged on both margins of the terete part of the stipe, a few lowermost ones at wide intervals but the middle and upper ones approximate and distinct, long cuneate, attaining 20 cm. in length, tapering towards the base into slender petiole, 2.0-3.5 cm. broad near the rounded apex, papyraceous, with plicate margins.

*Remarks on the affinity with other species.* KJELLMAN mentioned

the close affinity of this species with *A. esculenta* f. *typica*<sup>1)</sup> as well as with *A. Pylaii*, *A. membranacea* and *A. grandifolia* J. Ag. The resemblance of this species to *A. esculenta* GREV. is merely superficial. Both are readily distinguished by the disposition of sporophylls and by other characters. With *A. Pylaii* GREV. and *A. membranacea* J. Ag., as far as I understand these species, *A. dolichorhachis* KJELLM. has nothing to do.

A fully matured specimen of this species is not known to us. It can not, therefore, be ascertained whether the species belongs to the Holororia or to the Metasoria. The type specimen of *A. dolichorhachis* is provided with sporophylls yet faintly soriferous. So also *A. crispa* KJELLM. The sori appear to develop first in the lower halves of the sporophylls and then spread gradually upwards. In the specimen (No. 2101) under *A. muscifolia* J. Ag. in the Agardhian Herbarium, the sori begin to appear as an elliptical patch at a point a little below the middle of the length of each sporophyll. In both cases there is no sudden change of breadth in the soriferous and non-soriferous part. These examples lead me to assume, after considering the other species, that the present species belongs to the Holororia.

*Remarks on the synonyms.* Unfortunately I failed to study the type of *A. elliptica* in KJELLMAN'S collection at Upsala. Its co-type, collected at Pitlekay in July, 1849, was found in the Agardhian Herbarium at Lund (specimen No. 2082). Its stipe measures about 6 cm. in length, with numerous, long, cuneate sporophylls closely pinnately disposed. The midrib is about 3 mm. wide, much narrowed at the transition region. The blade is undulately plicated, acute at the base but abruptly broadened upwards.

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1) KJELLMAN: Alg. Arct. Sea, p. 218. No reference whatever for this form-name is mentioned by the author. He might have meant by it simply the typical form of *A. esculenta* GREV.



The specimen No. 2101, alluded to above, in the Agardhian Herbarium, was collected at Spitzbergen during the Torell Expedition and was compared by J. AGARDH with *Laminaria muscefolia* DE LA PYL. In Bidrag till Kännedomen af Spetzbergens Alger, Tillägg, however, J. AGARDH does not give any account on this specimen. He simply mentions two species of *Alaria* therefrom, *A. Pylaii* and *A. esculenta*, in the collection of the expedition. It is quite certain that the specimen mentioned has been treated as *A. Pylaii* in the Bidrag. This specimen is decidedly not applicable to *A. Pylaii* GREY. It agrees very well with the figure of *A. elliptica* in Alg. Arct. Sea, Plate 23, fig. 2, but in a little more advanced stage. A still slightly more advanced stage of this specimen is excellently represented by the co-type of *A. elliptica* just mentioned above.

In the Herbarium of the Botanical Museum of Upsala, there are two specimens as the type of *A. dolichorhachis* KJELLM. A third specimen collected by SETCHELL in Unalaska Bay is annexed to them, determined by KJELLMAN, but with a question mark. These three belong undoubtedly to one and the same species. I can not find any reason to treat them specifically distinct from the specimens of *A. elliptica* found in the Agardhian Herbarium. KJELLMAN himself observes a close affinity between *A. elliptica*, *A. dolichorhachis* and *A. praelonga*.<sup>1)</sup> The last mentioned species, however, is sharply distinguished from them. The descriptions of the other two can hardly give us the distinctions justifying their separation specifically. The describer emphatically states that the peculiarity of the shape of the blade of *A. elliptica* is its unique character. An examination of the type of *A. dolichorhachis*, in comparison with the co-type of *A. elliptica*, and considering the variation of the

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1) KJELLMAN: Algæ Arct. Sea, p. 232.

shape of the blade of *Alaria*, leaves me with little doubt about uniting the two species into one.

In describing *A. crispa* as an independent species, KJELLMAN seems to have put too much importance on the crisped base of the blade as well as on the characters shown in the cross sections of the midrib. These two points, however, as far as they concern the present case, can hardly be taken as specific distinctions. The shape of the cross section of the midrib and the distribution of the tissue elements shown in it, are to some extent variable, as has been demonstrated before. The crisping of the base of the blade is a character commonly met with in those *Alaria* which have a suddenly narrowed base. It shows that the growth of the blade in length is much quicker than that of the midrib at the transition region, and above this region the growth of the blade in width is more vigorous than in length, the midrib keeping nearly constant speed in the growth in length.

Comparing the type specimen of *A. dolichorhachis* KJELLM. with the illustrations in the *Algae of the Arctic Sea*, I think I have reason to say that they are quite misleading though not untrue. In the type, the sporophylls are much condensed within a short length of the stipe and have undulated margins; the blade is crisped or plicated. KJELLMAN himself has fully noticed the resemblance of this species and *A. crispa*. The types of these two are indeed inseparable. By merely consulting the illustrations of the former in *Algae of the Arctic Sea* and the latter in *Beringhafvets Algflora*, his remark on the affinity of both may not be properly understood.

A specimen from Petropaulowsk with deformed frond is kept in the herbarium of the Academy of Sciences of Petrograd determined by RUPRECHT as "*Alaria esculenta* var. *latifolia* forma

*singularis*." This, very likely, should be mentioned under this species.

KJELLMAN points out *A. esculenta* mentioned by HARVEY in Flora Esk., p. 49, to be probably referable to this species. In the herbarium of Trinity College, Dublin, I could not find any specimen which might be supposed to be the source of the information. I doubt if KJELLMAN consulted RATHROCK's sketches of algae before making the remark.

*Locality.* Spitzbergen (J. AGARDH); Pitlekaj (KJELLMAN); Koljushin Isle (KJELLMAN); Bering Sea (KJELLMAN); Konyam Bay (KJELLMAN); St. Lawrence Island (KJELLMAN); Unalaska Bay (SETCHELL); Agattu Island (SETCHELL and TOWNSEND); Petropaulowsk, Kamtschatka (RUPRECHT); Sakhalin (T. MIYAKE, Herb. S. A. C.).

*Alaria marginata* POST. et RUPR.

(Plate VI, fig. 1-4; Plate XIX, fig. 4.)

Illustr. Alg., p. 11.—SETCHELL: Critical Notes on Lam., p. 10.—COLLINS: Mar. Alg. Vancouver Isl., p. 110 (excl. var.).

= *Alaria lanceolata* COLL., HOLDEN et SETCH.: Phyc. Bor.-Amer. No. XLIV.

= *Alaria praelonga* SETCH. et GARDN.: Alg. N. W. Coast of N. Amer., p. 274.

= *Alaria cordata* TILDEN: Amer. Algae, No. 241.—SAUNDERS: Harr. Alaska Exped., Algae, p. 426, Pl. LVI.

= *Alaria striata* J. AG.: in Herb. J. AGARDH.

= *Alaria curtipes* SAUNDERS: Minn. Bot. Studies, Vol. II, p. 561, Pl. 33.

= *Phasganon marginatum* RUPR. Tange des och. Meeres, p. 355.

*Definition of the species.* Root, holdfast of dendritic ramification. Blade linear, 2-4 meters in length, 15-30 cm. in breadth, thick and coriaceous, finely striated when old, cryptostomata wanting,

margin entire, splitting in the older parts of the blade obliquely or almost transversely to the midrib; base of the blade acute with tapered end; tip of the blade narrowed above, pinnately cleft and generally roughly worn away. Stipe short, 5–10 cm. in length, subcylindrical below, 3–4 mm. in diameter, compressed and broadened upwards into a linear-cuneate form with the maximum breadth about 10–15 mm., narrowed at the transition point; lower half of the length naked, upper and complanated part, except the narrow region, bearing sporophylls. Midrib smooth, complanated, 20–28 mm. broad, elevated above the blade on both surfaces with slanting edges, continuous to the stipe below. Sporophylls holoserie, 10–20 in number, pinnately arranged but closely together on both margins of the complanated part of stipe, adding new ones successively upwards, 20–27 cm. in length, 4–5 cm. in breadth, linear-oblong, more or less curved or sigmoid, with well-defined, short, terete petioles; base of sporophyll obtuse, round or cordate, generally asymmetrical; tip roundish or obtuse. Sorus generally formed in a continuous patch on both surfaces of sporophyll, occupying the whole surface except a narrow border along the margin, very often a certain terminal portion of a sporophyll remaining sterile.

*Remarks on the species.* This species is easily distinguished from the others by the peculiarities of the sporophylls. Their size and substance are ample to tell the species. *A. fistulosa* alone may be compared with the present in this respect, but their roundish or cordate base is a character not duplicated in other species. The thick coriaceous substance of the blade and the complanated broad midrib also show unmistakable features of this species. A conspicuous fine striation on the older parts of the blade must also be mentioned as one of its remarkable specific distinctions. Briefly

speaking, the striation runs obliquely ascending from the midrib towards the blade margins, without relation to the pinnate cleaving. They are coarse at first, counting 10-12 streaks in 1 cm. in the dried specimens. The streaks ramify towards the blade margins so as finally to number 16-20 in 1 cm. The streaks are not continuous lines but are composed of small dots. These dots are also at regular intervals. Hence another striation results, though much more irregular, intersecting with the first one. The general appearance of such a portion of the blade may be roughly compared with the curved lines engraved on a watch-case by a rose-engine, or with finely shagreened leather.

*Remarks on the synonyms.* The present writer actually observed and collected *A. cordata* TILDEN at the type locality with the establisher of the species herself. So he may be permitted to say that his knowledge of the species is sufficient to distinguish it from the allied forms. On studying the type of *A. marginata* P. et R. in the herbarium of the Academy of Sciences of Petrograd, he was at once certain that both were one and the same species. SETCHELL and GARDNER<sup>1)</sup> remark that "as far as the incomplete description goes, *A. marginata* P. et R. seems to resemble *A. laticosta* KJELLM." They further note that *A. cordata* TILDEN seems to have no character to separate it from *A. Pylaii* GREV. This undoubtedly resulted from either their unsatisfactory acquaintance with a complete specimen of Miss TILDEN's, or otherwise the non-uniformity of the specimens in her exsiccatae.

HARVEY<sup>2)</sup> reported the occurrence of this species about Fuca Strait adjacent to Vancouver Island. Curious to say, the specimens kept under this species in the herbarium of Trinity College,

1) SETCHELL and GARDNER: *Algae of N. W. Coast of N. Amer.*, p. 275.

2) HARVEY: *Notices of a Collection of Algae, etc.*, p. 165.



Dublin, are all except one, *Cymathere triplicata*; and the excepted one is an incomplete specimen, which SETCHELL<sup>1)</sup> has identified with *Pleurophyceus Gardneri* SETCH.

DE TONI<sup>2)</sup> states that ANDERSON reported the present species from the Californian coast, but this statement has been apparently discredited by SAUNDERS.

A specimen of the present species is found in the Agardhian Herbarium at Lund bearing the name *A. striata* J. AG. This specific name originates undoubtedly from the fine striations on the matured blades. J. AGARDH once brought *A. marginata* P. et R. under *A. esculenta*<sup>3)</sup> but afterward discarded this view.<sup>4)</sup>

SETCHELL<sup>5)</sup> stated, after he had seen the original of *A. marginata* P. et R. in Petrograd, that the plant he and GARDNER referred to *A. prælonga* is really to be placed under *A. marginata* P. et R., and also that the plant distributed in the Phyc. Bor.-Amer., No. XLIV under the doubtful name of *A. lanceolata*, should be referred to the same species. He further expressed the view that *A. marginata* P. et R. may probably replace both the names of *A. prælonga* KJELLM. and *A. laticosta* KJELLM. On examining the originals of these two species at Upsala, I could by no means agree with his view. The specimen in the Phyc. Bor.-Amer., in a copy I have seen, was surely not of *A. marginata* P. et R. as noted under the preceding species. There must have been some non-uniformity in the exsiccatae.

A close affinity between *A. curtipes* SAUNDERS and *A. prælonga* KJELLM. has already been pointed out by SAUNDERS himself.<sup>6)</sup>

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1) SETCHELL: Critical Notes on Lam., p. 10.

2) DE TONI: Syll. Alg. III, p. 332.

3) J. AGARDH: Spec. Alg., p. 143.

4) J. AGARDH: Grönlands Lam. och Fuc., p. 23.

5) SETCHELL: Critical Notes on Lam. p. 10.

6) SAUNDERS: Harr. Alaska Exped., Algae, p. 561.

SETCHELL and GARDNER unhesitatingly announced the identity of both species. But what these two writers meant by *A. praelonga* KJELLM. is, as may be understood from the remark alluded to above, nothing but *A. marginata* P. et R. The figures sketched by SAUNDERS in Minn. Bot. Studies, l. c., Plate 33 show small specimens of the present species though not typical. It appears rather curious to me how he came to describe his plant as new, considering that he had already reported *A. cordata* TILDEN with illustration from Yaktat Bay. In Mar. Alg. of Vancouver Island, p. 110, COLLINS follows SETCHELL's amendment of *A. marginata* in bringing *A. curtipes* SAUNDERS under it. But that he mentioned *A. nana* SCHRAD. in its varietal rank shows his unfamiliarity with both species.

The specimen distributed by Miss TILDEN as No. 521 American Algae under *A. curtipes*, in the copy I have seen, agrees satisfactorily with *A. valida* SETCH. et KJELLM. And, No. 241 of the same exsiccata under *A. cordata* TILDEN can safely be identified with *A. marginata* P. et R.

*Locality.* St. Paul Island (TOWNSEND and SETCHELL); Yaktat Bay (SAUNDERS); Kadiak Island (SETCHELL); Unalaska (POSTELS and RUPRECHT); Juan de Fuca Strait (TILDEN); California (BERGGREN and J. AGARDH, in Herb. J. AG. under *A. striata*); Central California (SAUNDERS).

### *Alaria Pylaii* GREY.

(Plate VII; Plate VIII, figs. 1-2.)

Alg. Brit. Syn., p. XXXIX.—HARVEY: Alg. N.-W. Coast of N. Amer., p. 165.—J. AG.: Grönland Lam. och Fuc., p. 24.—Id.: Spec., I, p. 143.—SETCH. et GARDN.: Alg. N. W. Amer., p. 272.

- = *Alaria Pylaii* GREV. *a typica* ROSENV.: Grönl. Havalger, 1. 838.—Id.: DENX. Mém. p. 48.—JÖNSS.: Mar. Alg. East Greenl., p. 21.
- = *Alaria Pylaii* GREV. *β membranacea* ROSENV.: Grönl. Havalger, p. 839.
- = *Agarum Pylaii* BORY: in Dict. Class. IX, p. 194.
- = *Laminaria Pylaii* DE LA PYL: Flora Terr. Nouv., p. 29.
- = *Laminaria Despreauxii* BORY: mscr. (see J. AGARDH).
- = *Alaria membranacea* J. AG. *p.p.* Grönl. Lam. och Fuc., p. 26.
- = *Alaria esculenta* var. *latifolia* FARL.: Mar. Alg. New Engl., p. 97.
- = *Alaria tenuifolia* SETCH.: in COLL., HOLD. et SETCH.: Phyc. Bor.-Amer., Fasc. B. No. XLV. — SETCH. et GARDN.: Alg. N. W. Amer., p. 272. — SETCH.: Critical Notes on Lam., p. 12.
- = *Alaria tenuifolia* SETCH. f. *typica* SETCH.: in SETCH. et GARDN. Alg. N. W. Amer., p. 273, Pl. 22.
- = *Alaria tenuifolia* SETCH. f. *amplior* SETCH. et GARDN.: Alg. N. W. Amer., p. 274.
- = *Alaria fragilis* SAUNDERS: Harr. Alaska Exped., p. 425, Pl. 54.
- ?= *Alaria muscifolia* J. AG. *p.p.* Grönl. Lam. och Fuc. p. 23.
- ?= *Alaria esculenta* DICKIE: Algae Southerland, p. 140. (see ROSENVENGE).
- ?= *Laminaria esculenta* var. *remotifolia* DE LA PYL: in Ann. Sci. Nat. IV, p. 178, Pl. 9, Fig. E.

*Definition of the species.* Root, holdfast of dendritic ramification. Blade linear, 1–? meter in length, 12–20? cm. in breadth, membranaceous, frosted with cryptostomata, margin entire, undulating, splitting obliquely to the midrib in the older part; base of blade acute for a short length, suddenly expanding into an obtuse or even cordate form. Stipe 17–50 cm.\* in length, terete below, 3–4 mm.\* in breadth in the dried specimens, complanated for the greater part of the whole length, measuring 5–7 mm.\* in breadth, quickly narrowed at the transition point; lower half of the length naked,

\* The measurements with asterisks are from dried specimens.

upper half bearing the sporophylls, especially in the region near the base of the blade. Midrib smooth, complanated, 4–6 mm.\* broad, often as broad as 10 mm.,\* elevated above the blade on both surfaces with roundish edges. Sporophylls, metasoric, 20–30 or often more in number, pinnately arranged on both sides of the stipe, the lower ones much separated, gradually more approximate in the upper, adding new ones successively above, oblong-obovate, or elongate-elliptical, 8–15 cm.\* in length, 2.5–4.0 cm.\* in breadth, membranaceous, with well-defined, cylindrical petioles; base of sporophyll obtuse or round, sometimes asymmetrical; tip obtuse or round. Sorus on both surfaces of each sporophyll in a continuous patch, generally occupying the lower half of the whole area, and leaving a narrow border along the margin sterile.

*Remarks on the species.* The earliest appearance of the specific name *Alaria Pylaii* is in GREVILLE's *Algae Britannicae* Syn. p. XXXIX (1830). The name is formed by transferring *Agarum Pylaii* BORY (1826?) to the genus *Alaria* which he had then newly established. The specific limitation held by BORY or GREVILLE was naturally quite ambiguous, as the specimens from which the species has been described were very likely incomplete and sterile. The name practically covered all the forms of *Alaria* from the west side of the North Atlantic. In 1840, POSTELS and RUPRECHT reported three species of *Alaria* from the North Pacific, namely *A. esculenta*, *A. fistulosa* and *A. marginata*. J. AGARDH could not but acknowledge the marvelous plant *A. fistulosa* in his *Spec. Alg.*, I, but doubtingly mentioned *A. marginata* under *A. esculenta*. At this time, the Atlantic forms of *Alaria* belonged either to *A. esculenta* or to *A. Pylaii* in the opinion of the European algologists. In the collection from Greenland, J. AGARDH first came in contact

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\* The measurements with asterisks are from dried specimens.

with various forms of *Alaria* and undoubtedly with astonishment. He determined certain forms as *A. Pylaii* and others he divided into various new species. The concrete knowledge of *A. Pylaii*, though still ambiguous, held by modern algologists, we owe to the work of J. AGARDH "Grönlands Laminariaceer och Fucaceer." By the rule of priority, however, we have to mention GREVILLE as the establisher of the species. The specific limitation of course has gradually undergone much amendment and fluctuations since GREVILLE's time.

The ambiguity and uncertainty of *A. Pylaii* arose first of all from the fact that the early algologists had an insufficient knowledge of the variation of the forms according to the stages of development as well as to the condition of the place where the plant grows. In the second place, authentic specimens distributed by the establisher of the species have not been uniform or else some of the later referrers to the species have not properly consulted the original specimens. The original of *Laminaria Pylaii* was from Newfoundland. Specimens from Greenland, Spitzbergen, Vancouver Island, B. C., &c., were identified with it. Some of these, however, as it appears to me, have been so identified merely because either the sporophylls were soft, membranaceous and distant, or the blade thin and its base round.

In the first-year fronds of *A. esculenta* GREV., *A. prælonga* KJELLM. and *A. grandifolia* J. AG. (= *A. oblonga* KJELLM.), etc., the sporophylls are often oblong and distant. In such a stage, the substance of the frond is naturally soft and membranaceous and the stipe very slender. It is not unlikely for a herbarist to refer such a form, when the specimen has come from a colder sea of the North Atlantic, to *A. Pylaii* GREV. One might mistake with excuse a specimen as illustrated by KJELLMAN in Alg. Arct. Sea,



Pl. 23, fig. 1 under *A. elliptica* KJELLM. as a form of the present species if the specimen had not been growing with a matured form of *A. oblonga* KJELLM.

Most species of *Alaria*, as far as the observations of the present writer extend, when grown in quiet water of less salinity, are more or less liable to have the stipe long, the blade thin, soft and broad, the sporophylls thin, broad and few in number, in a greater degree than the species typically ought to have; in a word, more or less approaching in the general aspect the present species. Therefore, the collector should be warned when he has found an *Alaria* resembling *A. Pylaii* GREV. to pay special attention to the condition of the place where it was growing.

*Remarks on the synonyms.* I have seen neither the original specimen of *Agarum Pylaii* nor of *Laminaria Pylaii* DE LA PYL. J. AGARDH remarks in Spetzbergens Alger, Tillägg, p. 30, that he thinks *Agarum Pylaii* BORY to be different from *Laminaria Pylaii* DE LA PYL. and compares the latter with *Phusganon macropterum* RUPR. It is now almost impossible to decide the exact specific limitations of the two.

BÖRGESEN<sup>1)</sup> announces that *A. Pylaii* is founded by J. AGARDH from BORY's species. The priority of the specific name, as alluded to above, must be given to GREVILLE. The modern specific conception comes down since J. AGARDH has modelled from the Greenland specimens. He has not based his opinion upon BORY's specimens, as he says BORY's *Agarum Pylaii* is rather a doubtful species. Cfr. Grönlands Lam. och Fucaceer, p. 24. One of the specimens kept in the Agardhian Herbarium at Lund (No. 2094) bearing the name "*Laminaria Pylaii* BORY" is a young and sterile form not positively determinable as to species (Plate VIII). Another specimen (No. 2091)

1) BÖRGESEN: Mar. Alg. of the Faeröes, p. 451.

is a matured form referable to *A. esculenta* GREV. with utmost certainty. Again, *Laminaria Despreauxii* BORY is represented in the Herbarium by a single specimen, very likely one of the specimens distributed by DELISE under the name. This specimen is kept in the Herbarium in the species cover of *A. Pylaii*. RUPRECHT<sup>1)</sup> has also remarked that *Laminaria Despreauxii* BORY agrees with *Agarum Pylaii* BORY. Consulting the specimen in the Agardhian Herbarium, the plant is undoubtedly a fully matured, first-year form of *A. Pylaii* GREV., with the sporophylls fully developed and the greater part of the blade rubbed away (Plate III).

*A. membranacea* J. AG. mentioned in Grönl. Lam. och Fue., p. 26, should undoubtedly be amalgamated with the present species, as has been already stated by ROSENVENGE.<sup>2)</sup> The specimen from Greenland kept in the Agardhian Herbarium shows that it is a young form with thin and membranaceous blade and a few young and sterile sporophylls. On the other hand, however, some of the specimens from Spitzbergen are inseparable from *A. grandifolia* J. AG., while some others are comparable with the Greenland specimens. The former circumstance has already been noted by KJELLMAN<sup>3)</sup> who states emphatically that the young individuals of *A. grandifolia* J. AG. collected in Spitzbergen answer in all particulars to *A. membranacea* J. AG. He goes as far as to say, "alla de unga skulle tillhöra en art, men alla äldre utan undantag en annan." He<sup>4)</sup> also admits that *A. membranacea* has a certain resemblance to *A. Pylaii* GREV.

*Laminaria muscifolia* DE LA PYL is a species very hard to understand. The description and figure given by the author are

1) RUPRECHT: Tange des och. Meeres, p. 358.

2) ROSENVENGE: Grönlands Havalger, p. 839.

3) KJELLMAN: Spetzbergens Thallophyter, II, p. 12.

4) KJELLMAN: Alg. Arct. Sea, p. 216.

applicable to more than one species in our present conception. In the Agardhian Herbarium, it is represented by a portion of a blade, cleft decussately from the midrib, recalling a *Musa* leaf (Specimen No. 2105). It may or may not be *Alaria Pylaii* GREV. In Grönlands Lam. och Fucac., p. 23, J. AGARDH brings various "species" to synonymous positions with *A. muscæfolia* (DE LA PYL). It is a question how far this synonymization may be relied upon. DE TONI<sup>1)</sup> entirely follows J. AGARDH's view and further adds *A. esculenta* f. *muscæfolia* KJELLM. to the synonym list. KJELLMAN states in Spetzbergens Thallopkyter, II, p. 12, "Mellan *A. esculenta* och *muscæfolia* är skillnaden icke betydlig." This is perhaps why he proposes the forma. But KJELLMAN's specimen of f. *muscæfolia* can never be compared with "*L. muscæfolia* DE LA PYL" in the Agardhian Herbarium. The specimen from Spitzbergen (No. 2101) bearing the name is beyond doubt to be identified with *A. dolichorhachis* KJELLM.

*A. tenuifolia* SETCH. and f. *amplior* are inseparable from the Greenland form of *A. Pylaii*. The specimen collected by LYALL at Esquimalt, Vancouver Island, B. C., identified by HARVEY as *A. Pylaii* GREV. and now kept in the herbarium of Trinity College, Dublin, is a young individual with immatured sporophylls, but satisfactorily agreeing with *A. tenuifolia* SETCH. f. *typica*. SETCHELL states in Fertilizer Resources of the United States, p. 162, "*A. tenuifolia* SETCH. is to be distinguished by its long, flattened stipe, only moderately broad midrib, short and relatively broad sporophylls and blade broadly cuneate at the base." This statement holds equally good for the Atlantic form of *A. Pylaii* GREV. An examination of the type specimen of *A. membranacea* J. AG. induces us to come to the conclusion as SETCHELL who says that

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1) DE TONI: Syll. Alg. III, p. 327.

they are far from satisfying. Some of them are indeed difficult to separate from what J. AGARDH calls *A. grandifolia*. Others (for example, No. 2111), though not fully matured, are hardly specifically distinct from *A. tenuifolia*.

SETCHELL and GARDNER<sup>1)</sup> in their joint work amalgamated *A. fragilis* SAUNDERS with *A. Pylaii* GREV. The author of the species<sup>2)</sup> notes that it “differs essentially from the description of *A. Pylaii* GREV. in having a long stipe and the sporophylls few and distinct.” But what he points out as the peculiarities of his species are nothing but those of *A. Pylaii* GREV. The author also quotes KJELLMAN’S view on his plant, viz., “Dr. KJELLMAN compares this plant to HARVEY’S specimen labelled *A. Pylaii* GREV. from Vancouver Island, but he agrees that HARVEY’S specimen is distinct from *A. Pylaii* of the Atlantic and Polar Seas and is an undescribed species.” But as above stated, HARVEY’S specimen does not give any support to this view. It is to be stated here that the description and figure of the species by SAUNDERS are to a great extent applicable to *A. elliptica* KJELLM. The latter species is in my opinion the same as *A. dolichorhachis* KJELLM. and identical with what J. AGARDH labelled *A. musæfolia* J. AG. from the Spitzbergen collection. Some of its forms resemble in a certain degree *A. grandifolia* J. AG. and to *A. Pylaii* GREV. as well.

The synonymization of *A. esculenta* var. *latifolia* FARL. in the list above given is wholly on the authority of SETCHELL’S view in Phyc. Bor.-Amer., No. XCIV.

*Locality.* North-west coast of Europe; Færøese Islands (BörgeSEN), Beeren Island (KJELLMAN), Trömsö (KJELLMAN), Finmarken (KJELLMAN): Greenland; Hekla Havn (ROSENVENGE), Smalsund

1) SETCHELL and GARDNER: Alg. N. W. Amer., p. 278.

2) SAUNDERS: Harr. Alaska Exped., Algae, p. 425.

(JÖNSSÉN): Greenland side of Baffin Bay; Julianshaab, Sukkertoppen, Jakobshavn, Claushavn (J. AGARDH): North-west coast of North America from Unalaska to Puget Sound; Kadiak Island, Orca (SETCHELL), Kukak Bay, Prince William Sound, Glacier Bay (SAUNDERS), Vancouver Island (LYALL, HARVEY).

*Ataria crassifolia* KJELLM.

(Plate IX, figs. 1-3; Plate X, figs. 1-3; Plate XVIII, figs. 1-18.)

KJELLM. och PETERSEN: Om Japans Lamin., p. 276, Tab. X, fig. 9-12.—DE TONI: Syll. Alg. III, p. 330.—OKAMURA: On Laminaria of Japan, p. 99.—MIYABE: Lamin. of Hokkaido, p. 54, Pl. 23 (in Japanese).

*Definition of the species.* Root, holdfast of dendritic ramification. Blade linear-lanceolate, 0.5-1.5 meters in length, 5-20 cm. in breadth, membranaceous but leather-like when old, richly frosted with cryptostomata on both surfaces, margin entire, splitting in the older parts of the blade obliquely or almost transversely towards the midrib; base of blade generally acute, but often abruptly expanded at some distance above the transition point; tip of blade narrowed above, pinnately cleft and generally roughly eroded away. Stipe 4-15 cm. in length, cylindrical below, 2-3 mm. in diameter, gradually terete and broadened above, measuring 3-4 mm. in width, but quickly narrowed at the transition point; lower half of the length naked, upper and compressed part except the narrowed region bearing the sporophylls. Midrib smooth, complanated, 2-6 mm. broad, elevated, often prominent above the blade on both surfaces with angulate edges, continuous to the stipe below. Sporophylls, metasoric, numerous, pinnately arranged on both margins of the complanated part of the stipe, a few lowermost



ones at wide intervals, but middle and upper ones approximate and regularly disposed, adding new ones successively upwards, long linear, 5–20 cm. in length, with well-defined cylindrical petioles; base of sporophyll acute or obtuse, very often asymmetrical; tip, when entirely soriferous, attenuate with obtuse apex, and when partially soriferous the upper sterile part often abruptly expanded with round margin. Sorus generally formed in a continuous patch on both surfaces of each sporophyll, occupying the entire surface except a narrow border along the margin, resulting in a considerable thickness of the sporophyll; or often leaving a sterile portion at the upper part of the sporophyll. In the latter case, the upper limitation of the sori is gradual and faint.

*Remarks on the limit of variations.* The species is characterized by having unrivalled thick sporophylls when they become fully matured. MIYABE states, l. c., p. 54, that the margins of immature sporophylls are finely serrated. But this statement is resulted from a false observation of the fine crispation of the sterile margins frequently met with, certainly due to the greater growth of the marginal parts than the soriferous area (Plate X).

In the mode of attachment of sporophylls to the stipe, the present species agrees exactly with *A. esculenta* GREV. While the sporophylls have not yet matured and the peculiarity of the species is not conspicuously manifested, both species are hardly separable one from the other.

Specimens from the type locality have generally the matured sporophylls enormously thickened and frequently entirely free from the sterile portion, as illustrated by KJELLMAN. Very often, however, the upper part of some sporophyll is broadened and remains sterile and membranaceous for the whole life. This aberrancy grows greater and greater as we trace the species towards

the eastern and the southern coast, considering the type locality as the center of its distribution.

*Remarks on the relationship to other species.* The present species has a close resemblance in many respects to *A. esculenta* of the Atlantic coasts. If both had been found near each other, one might well have been taken as a variety of the other. The only and marked distinction between them lies in the considerable thickening of the matured sporophylls of the present species. The species, however, has only a limited area of distribution and can not in any way represent in the Pacific the position of *A. esculenta* in the Atlantic.

The specimens collected on the coast of Hidaka Province generally have the sporophylls much thinner and broader than the typical form and the matured ones apparently holosoric. The characteristic arrangement of the sporophylls is obliterated in them. They are to be determined as *A. praelonga* KJELLM. better than as the present, if the blades had not been frosted with rich cryptostomata. It is not seldom to find a specimen which appears to link the two species. This view is much strengthened by the relative positions of their distributive areas. *A. praelonga* is found in the southern part of Kamtschatka, and then along the Kurile group as far south as near Cape Erimo, Hidaka Province, on the coast of Hokkaido. It there disappears and in its stead the present plant occupies the coasts further south-westward. As the intermediate forms are usually confined to about the crucial region of the two species, one might be regarded as a variety of the other due to the locality. The typical forms of both, however, are so well marked that I can not bring them together in our present conception of species.

A parallel example may be given in *Laminaria*. The vicinity

of Cape Erimo is a frontier of *Laminaria longissima* MIYABE,<sup>1)</sup> a Kurile species, and *L. angustata* KJELLM. which has exactly the same distributive area as *A. crassifolia*. Both species of *Laminaria* are very much alike, but are still distinct.

*Locality.* Hakodate (KJELLMAN and PETERSEN)(!); Todohokke (MIYABE); Shitsukari (MIYABE); Muroan (MIYABE); Urakawa (MIYABE); Kamaishi, Rikuchu Prov. (Y. TANAKA); Tashiro-jima, Rikuzen Prov. (Y. TANAKA); Oma, Mutsu Prov. (!).

### *Alaria esculenta* GREV.

(Plate XI, fig. 1-3.)

- Alg. Brit., p. 25, Pl. IV.—HOOKER: Brit. Fl. II, p. 271.—ENGL. Bot.: Pl. 1759.—KÜTZ.: Phyc. Gen., p. 347, Taf. 32, Fig. 1 (excl. synonym.).—HARV.: Phyc. Brit. Pl. 79 (excl. synonym.).—Id.: Manual, II Edit., p. 29, Pl. 3.—J. AG.: Spec. Alg. I, p. 143 (excl. synonym.).—Id.: Grönl. Lam. och Fuc., p. 22.—STRÖMF.: Algenveg. Island Kuster, p. 38.—KJELLM.: Alg. Arct. Sea, p. 212.—Id.: Handbok, p. 19.—BÖRGES.: Alg. Faeröes p. 448 (excl. var. *pinnata*).—Id.: Mar. Alg. Shetlands, p. 5.—COLL., HOLD. et SETCH.: Phyc. Bor.-Amer., Fasc. D, No. XCIII.—ROSENV.: Om Frem. Alger Jullands Vestkyst, p. 94.  
 = *Fucus esculentus* L.: Mantissa, p. 135.  
 = *Fucus esculentus* LYGHTE.: Flora Scot., Tab. 117.—STACKH. Ner. Brit., Tab. 29.—TURNER: Hist. Fuc., Tab. 117.  
 = *Fucus esculentus* GUNN.: Acta Nidaro, IV, Tab. VIII, Fig. 1.  
 = *Fucus teres* GOOD. et WOODW.: in Trans. Linn. Soc., III, p. 140.  
 = *Fucus tetragonus* GOOD. et WOODW.: in Trans. Linn. Soc., III, p. 140.  
 = *Ceramium esculentum* STACKH.: Ner. Brit., p. XXIV.  
 = *Musefolia esculenta* STACKH.: in Mem. Soc. Mosc., II, p. 66.  
 = *Orgyia esculenta* STACKH.: Ner. Brit. Edit. II, p. 98.  
 = *Phasganon esculentum* GRAY: Arrang. Brit., Pl. I.

1) MIYABE: Lam. of Hokkaido, p. 37, Pl. 4.

- =*Laminaria esculenta* LAMX.: Essai Thalass., p. 22.—AG.: Synopsis, p. 16.—Id. Systema Alg., p. 269.—Id.: Spec. Alg., p. 110.—STRÖMF.: Act. Havn, 10, Tab. F, fig. 2.—LYNGB.: Hydrophyt. Dan., p. 23.
- =*Laminaria esculenta taniata* DE LA PYL.: Flora Terr. Nouv. in Ann. Sci. Nat., IV, p. 177.
- =*Laminaria esculenta* var. *Noltii* HORNEB.: Dansk Oekon. Plant, II, p. 737.
- =*Laminaria linearis* DE LA PYL.: Flora Terr. Nouv., p. 37.?
- =*Laminaria Noltii* AG. in litt. (Herb. Trinity Coll., Dublin).
- =*Alaria muscifolia* KJELLM. Algenveg. Murm. Meeres, p. 35.
- =*Alaria esculenta* f. *australis* KJELLM.: Alg. Arct. Sea, p. 212.
- =*Alaria esculenta* f. *muscifolia* KJELLM.: l. c.
- =*Alaria esculenta* f. *pinnata* FOSL.: Mar. Alg. Norw., I, p. 71 (excl. synonym.).
- =*Alaria esculenta* f. *typica* EÖRGES.: Alg. Faeröes, p. 449.
- =*Alaria esculenta* f. *fasciculata* STRÖMF.: Algenveg. Island Kuster, p. 38.
- =*Agarum esculentum* BORY: Diet. Class. IV, p. 194.
- ?=*Alaria esculenta* HARV.: in Smith. Inst. for 1867, p. 463.

*Definition of the species.* Root, holdfast of dendritic ramification. Blade linear-lanceolate, 1–6 meters long, 5–20 cm. broad, membranaceous, frosted with cryptostomata on both surfaces, margin entire, splitting in the older parts of the blade obliquely towards the midrib; base of blade gently tapering below when young, acute in adults; tip of blade narrowed above, generally pinnately cleft and roughly worn away. Stipe 8–20 cm. in length, subcylindrical below, 2.5–3.0 mm. in diameter, gently broadened and terete upwards, measuring 4–6 mm. in width, but quickly narrowed at the transition point; lower half of the length naked, upper half bearing the sporophylls. Midrib smooth, complanated, elevated above the blade equally on both surfaces with angulate edges, continuous to the stipe below. Sporophylls, metasoric, numerous, pinnately arranged on both margins of the complanated part of

the stipe, a few lowermost ones at wide intervals, but middle and upper ones approximate and regularly disposed, adding new ones successively upwards, narrow cuneate, 5-15 cm. in length, tapering gently into cylindrical petioles towards the attachment point to the stipe; tip round or obtuse. Sorus in a continuous patch with sharp boundary on both surfaces of each sporophyll, occupying lower half area of the surface except a narrow border along the margin.

*Remarks on the limit of variation.* In Illustr. Alg., POSTELS and RUPRECHT distinguished various formæ under the present species, viz., *angustifolia*, *latifolia* and *pinnatifida*. As will be stated below, the specific conception taken by these authors is much wider than as we now define the species. The three formæ, therefore, must be separated from the present heading. What are meant by these formæ will be treated later on.

FARLOW mentions a variety of the present species, var. *latifolia*, in Marine Algae of New England, p. 97. It has been referred to *A. Pylaii* GREV. by SETCHELL. Cfr. Phyc. Bor.-Amer., No. XCIV.

KJELLMAN distinguished two formæ, f. *australis* and f. *musæfolia*, and referred to some old descriptions under each name. But the specimens collected by FOSLIE at Lödingen and determined by KJELLMAN as f. *musæfolia*, now kept in the Agardhian Herbarium, do not agree with the authentic specimens of *Laminaria musæfolia* DE LA PYL in important points and are nothing but a typical form of *A. esculenta* GREV.

STRÖMFELT distinguished a form with densely aggregated sporophylls under f. *fusculata*. BÖRGESEN<sup>1)</sup> remarks that this form comes quite near to what he called *A. esculenta* f. *typica*. He mentioned another form, f. *pinnata* and refers to *Fucus pinnatus*

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1) BÖRGESEN: Mar. Alg. Færöes, p. 449.



GUNN. It is to be remarked here that in Tange des oehotischen Meeres, p. 364, RUPRECHT says: "*Alaria esculenta pinnatifida* Illustr. Alg. p. 11 vielleicht mit Ausschluss des synonyme von GUNNER, ist die fiederförmig eingeschnittene Form, die wohl bei dem breit —als auch schmalblättrigen *Ph. alatum* und den übrigen unsicheren Arten vorkommen kann."

The plant undergoes various modifications in the shape of the frond according to its environment. In some cases, when it grows in an open sea with comparatively rough water and full sunlight, the blade becomes longer and the sporophylls generally approximate, narrower and longer, as to agree with f. *fasciculata* STRÖMF. On the other hand, the plant has some tendency to approach *A. crassifolia* KJELLM., especially when the sporophylls are entirely soriferous and much thickened. The present writer holds the view that these two species are very closely related to one another, the former inhabiting the Atlantic and the latter the Pacific, acquiring more or less distinct local characters.

Some authors regarded the general shape of a cross section of the midrib as important enough for specific distinction. RUPRECHT, STRÖMFELT, GUNNER, etc., have mentioned various species based on this character, while otherwise they may be taken as mere forms within the specific limitation of *A. esculenta* GREV. BÖRGESSEN also applied the character in separating *A. esculenta* and *A. Pylaii*. He, however, notes that the young specimens of *A. esculenta* often have midribs which must properly be called two-edged. As this question is not yet fully settled, I do not at present attempt to amalgamate the two imperfectly known species, *A. linearis* STRÖMF. and *A. flagellaris* STRÖMF., with the present species.

However the frond may vary in the shape, the mode of

arrangement of the sporophylls is nearly constant and unrivalled in its regularity among the Atlantic members of the genus. When the sporophylls are densely aggregated, the plant may often show a character comparable with *A. grandifolia* J. Ag. On the contrary, when they are widely separated, such as in an immature specimen, the plant may often be taken as a form of *A. Pylaii* GREV. In the present species the narrow cuneate sporophylls and their regular arrangement, with each petiole distinctly separated, are well defined and most important characters for distinguishing it from its allied species.

*Remarks on the synonyms.* In the sense of the old writers, *Fucus esculentus*, now called *Alaria esculenta*, covers almost all species of what at present we bring under the genus *Alaria*. Even to such a keen observer as HARVEY, distinctions between various specimens accessible to him have not been regarded as important enough for separation into independent specific rank. In the floristic lists of the North Pacific, written by early writers, therefore, the name *Alaria esculenta* is repeatedly mentioned. The Pacific Ocean, however, does not produce this species so far as our present researches extend, hence the specific name in such lists does not mean more than "*Alaria* sp."

When RUPRECHT worked out Tange des ochotischen Meeres, he distinguished three species of *Alaria*, viz., *A. esculenta*, *A. fistulosa* and *A. marginata*. He chose, however, to call them by the genus *Phasganon* instead of *Alaria*, and *A. esculenta* was synonymized under *Phas. alatum*, which specific name he found in CARGILL's work. It is therefore quite natural that we find various different species of *Alaria*, in our specific conception, from the North Pacific under the species cover of *Phas. alatum* in the herbarium of the Academy of Science of Petrograd. Two authentic

specimens from RUPRECHT are now kept in the Agardhian Herbarium at Lund, one annexed with *A. praelonga* KJELLM. and the other with *A. angusta* KJELLM. In Grönlands Lam. och Fucaceer, p. 23, J. AGARDH notes that RUPRECHT's specimens come quite near *A. esculenta*. Another specimen distributed by RUPRECHT under *Phas. alatum* is to be found in the Botanical Museum of Berlin, and to me it seems to belong to *A. valida* SETCH. et KJELLM.

The name *Fucus alatus* established by CARGILL in 1620 may be the first botanical name proposed for the plant. This is why RUPRECHT has chosen to call the plant *Phasganon alatum*, and a lengthy history of the name is given by him in his Tange des ochotischen Meeres, p. 266-377. To cast away the name *Alaria esculenta* so commonly known to us, giving the priority to a pre-Linnean ambiguous description, seems by no means acceptable.

The name *Fucus pinnatus* GUNN. is found placed in a synonymous position under various species by different writers. In Grönlands Lam. och Fucaceer, p. 23, J. AGARDH refers to it under *A. muscefolia*, regarding it as a synonym of *Laminaria muscefolia* DE LA PYL. In Illustr. Alg., p. 11, POSTELS and RUPRECHT mention the name under *A. esculenta* f. *pinnatifida*. This forma is discussed by RUPRECHT in Tange des ochotischen Meeres, p. 364, under *Phas. alatum* var. *pinnatifida*, and he seems to hold the view that the pinnately cleft blade is indifferent to the age of the plant but is a peculiarity of the species or forma. In the latter work he excluded GUNNER's species as a synonym of the forma mentioned in Illustr. Alg. The original specimens in the herbarium of the Academy of Science of Petrograd show that they are to be separated into more than two species, simply having the pinnately cleft blades as a common character.

HARVEY<sup>1)</sup> mentions *Fucus pinnatus* FL. NORV. as a synonym of *A. esculenta* GREV. The same view is adopted by the Scandinavian algologists such as KJELLMAN,<sup>2)</sup> FOSLIE,<sup>3)</sup> BÖRGESSEN,<sup>4)</sup> and JÖNSSON.<sup>5)</sup> GOBI<sup>6)</sup> also holds the same view but chose the name *Orgyia pinnata* instead of *A. esculenta* GREV. on account of priority. He further stated that some of the specimens which he calls *Orgyia pinnata* seem to stand very near “f. *membranacea* J. AG.”<sup>7)</sup> This resulted in an ambiguous disposition of GOBI’s species in DE TONI’S Syll. Alg., III, p. 327, in which *Orgyia pinnata* GOBI is found in a synonymous position under *A. membranacea* J. AG.

The views enumerated above are so widely divergent from each other that I am unable even to model a general character of the plant. I have not seen GUNNER’S type specimen nor any co-type of it. GUNNER’S original description and illustration can not help us to catch the exact specific characters in the modern sense. It is, however, almost beyond doubt that the plant which GUNNER has designated as *Fucus pinnatus*, occurring on the Norwegian coasts, must have been *A. esculenta* GREV.

RUPRECHT seems to have believed that *Fucus platycarpus* GMEL., illustrated in Hist. Fuc., Pl. XXXI, might have been a stipe of *A. esculenta* or as he later calls it, *Phas. alatum*. But what GMELIN has figured is undoubtedly a stipe of an old and decayed plant of *Thalassiophyllum clathrus*. Specimens exactly agreeing with GMELIN’S figure may be found everywhere on the coasts of the northern

1) HARVEY: Phyc. Brit. Pl. 79.

2) KJELLMAN: Handbok, p. 29.

3) FOSLIE: Mar. Alg. Norway, I, p. 71.

4) BÖRGESSEN: Mar. Alg. Færøes, p. 418.

5) JÖNSSON: Mar. Alg. of East Greenl. p. 24.

6) GOBI: Alg. Weissen Meeres, p. 77.

7) GOBI simply mentions this form-name without giving any hint as to which species this forma should belong. So far I could refer to, such form-name has never been proposed by J. AGARDH for either *A. esculenta* or *A. Pylaii*.

Kuriles and southern Kamtschatka after a stormy weather during August-September.

Again, RUPRECHT<sup>2</sup> considers *Fucus fimbriatus* GMEL., Hist. Fuc., Pl. XXIXa, to be referable to *A. esculenta*  $\beta$  *latifolia* P. et R. But judging from the figure, I believe that it may be *Cymathere triplicata* J. AG.

The original specimen of *A. esculenta* f. *muscefolia* KJELLM. in the Herbarium of the Botanical Museum of Upsala shows all the characters of *A. esculenta* GREV., so it is not worth mentioning under a special forma. In Spetz. Thall., II, p. 12, KJELLMAN states, "Mellan *A. esculenta* och *muscefolia* är skillnaden icke betydlig." By "*muscefolia*" KJELLMAN certainly means *A. muscefolia* J. AG. As may be understood from what has been stated on p. 91 and 102, *A. muscefolia* J. AG. can not be identical with *Laminaria muscefolia* DE LA PYL, and shall be referred to *A. dolichorhachis* KJELLM. The limitation of DE LA PYL's species seems to me to vary greatly as the writers differ. This question will be treated under *Laminaria muscefolia* DE LA PYL.

HARVEY mentions *A. esculenta* from Alaska based on RATHROCK's sketches of the algae of Alaska. SETCHELL and GARDNER mention this reference under *A. esculenta* GREV. In the Herbarium of Trinity College, Dublin, there was no specimen which could be supposed as its source. HARVEY may have identified it simply by the sketch. It is quite impossible to imagine to which species of *Alaria* the sketch was referable. In HARVEY's time, botanists had a poor knowledge of the *Alaria* of the North Pacific. KJELLMAN hesitatingly referred to the information under *A. dolichorhachis*, as noted on p. 93.

*Locality.* Mototschikin Sharr, Rogatschin Bay, Nova Zembla (KJELLMAN, under *A. muscefolia*); Maasö (KJELLMAN), Svärtholt



(FOSLIE), Mehaon (FOSLIE), Mandal (WILLE), Norway ; Fanö (ROSEN-  
VENGE), Denmark ; Roscoff, France (SAUVAGEAUX) ; Færøese Islands  
(LYNGBYE, BÖRGESEN, etc.) ; Iceland (LYNGBYE) ; Shetland (BÖRGE-  
SEN) ; Clare Island (COTTON) ; Cumberland (HUDSON and HARVEY) ;  
Anglesea and Isle of Man (DAVIES and HARVEY) ; Durham and  
Northumberland (WINCH and HARVEY) ; Cornwall (TURNER) ; North  
coast of Devonshire (MRS. GRIFFITHS and HARVEY) ; Weymouth  
(STACKHOUSE) ; Orkney (CLOUSTON) ; Angmagsalik (ROSENVENGE, under  
*A. flagellaris*), Tasinsak (JÖNSSSEN under *A. esculenta* var. *pinnata*  
KJELLM.), Greenland.

*Alaria valida* SETCH. et KJELLM.

(Plate XII, figs. 1-3.)

In SETCH. and GARDN. : *Algæ N. W. Amer.*, p. 278, Pl. XXI.—  
SETCH. : *Critical Notes on Lam.*, p. 11.—Id. : *Kelps U. S. and Alaska*,  
p. 163.

= *Alaria valida* f. *longipes* SETCH. et GARDN. : *Algæ N. W.*  
*Amer.*, p. 279.

= *Alaria curtipes* TILDEN : *Amer. Algæ*, No. 521.

= *Alaria grandifolia* COLLINS : *Mar. Algæ of Vancouv. Island*,  
p. 110.

*Definition of the species.* Root, holdfast of dendritic ramifica-  
tion. Blade linear lanceolate, 3-4 meters in length, 15-25 cm. in  
breadth, coriaceous, cryptostomata wanting, margin entire, undulat-  
ing, splitting in the older parts of the blade obliquely towards the  
midrib ; base of blade attenuated for a short length, soon expand-  
ing upwards into an acute form. Stipe 6-10 cm. in length, lower  
half cylindrical, 3-5 mm. in diameter, gently terete and broadened  
above, but narrowed again at the transition point, the cylindrical  
part naked, the upper terete part bearing the sporophylls. Midrib

smooth, complanated, elevated above the blade equally on both surfaces with angulate edges, continuous to the stipe below. Sporophylls metasoric, 8–15 in number, pinnately arranged on both margins of the complanated part of the stipe, a few lowermost ones distant, but middle and upper ones disposed at short regular intervals, adding new ones successively upwards, linear-lanceolate, 15–50 cm. in length, 3–6 cm. in breadth, with a well-defined, short, terete petiole, margin undulate; base acute; apex varying from acute to roundish. Sorus in a continuous patch on both surfaces of each sporophyll occupying nearly the whole area of surface of sporophyll except a narrow border along the margin and often a small portion of the tip.

*Remarks on the synonyms.* This species was first described by SETCHELL under joint authorship with KJELLMAN in the paper cited above. He reserved the identity of the species with *A. marginata* as a question. Afterwards, in Critical Notes, l. c., he stated that his examination on the type of *A. grandifolia* J. AG. in the Agardhian Herbarium convinced him of the identity of *A. grandifolia* and *A. valida*. The specimen distributed as Phyc. Bor.-Amer., No. CV, under *A. grandifolia* J. AG. by COLLINS, HOLDEN and SETCHELL seems to have been placed by following this view. It agrees well with the description given in *Algae N. W. Amer.*, p. 278. Although it is noted on the label of the exsiccata: "The plant here distributed are of longer form agreeing well with J. AGARDH's description and type specimen," the specimen in the copy I have seen shows a marked difference from any of the type specimens of *A. grandifolia* J. AG. The type specimens are distinguished by J. AGARDH into three formæ, *junior*, *intermedia* and *adultæ*. They are equally provided with long, narrowly cuneate sporophylls. The stipe is very stout, the largest one measuring

45 cm. in length, in dried state as thick as the middle finger, cylindrical below and gradually terete above. The specimen in the Phycotheca has the stipe cylindrical nearly to the transition region, hardly 3 mm.\* in diameter, the sporophylls are linear-oblong, with roundish bases and sharply defined, short petioles. In the shape and texture of sporophyll the plant approached very much *A. marginata* P. et R., but differed from it by having a distinctly narrowed midrib and in the mode of sporophyll arrangement. I wrote my questions on these points to Prof. SETCHELL and requested him to spare me a typical specimen of *A. valida*. He was kind enough to favour me with two well-prepared specimens. They are quite similar to the specimen above remarked, hence I have no more hesitation in mentioning the plant as a valid and well-defined species. In his latest work "The Kelps of the United State and Alaska," p. 163, SETCHELL mentions *A. valida* in an independent specific position.

The specimen distributed by Miss TILDEN under *Alaria curtipes* as American Algae, No. 521, in the copy I have seen, is to be identified with the present species. SETCHELL and GARDNER<sup>1)</sup> compared the description of *A. curtipes* SAUNDERS with *A. praelonga* KJELLM. Her specimen, however, does not agree with the description, and its sporophylls show the characteristics of the Metasoria.

*Locality.* Unga, Alaska (SETCHELL); Whidby Island (GARDNER).

*Alaria nana* SCHRADER.

(Plate XIII, figs. 1-3.)

Minn. Bot. Stud., III, Part II, p. 157, Pl. 24-26.

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1) SETCHELL and GARDNER: Algae N. W. Amer., p. 274.

= *Alaria praelonga* f. *nana* SETCH. : in COLL., HOLD. and SETCH. :  
Phyc. Bor.-Amer., No. 1292.

= *Alaria marginata* f. *nana* COLLINS : Mar. Alg. of Vancouver  
Island, p. 110.

*Definition of the species.* Root, holdfast of dendritic ramification. Blade linear-lanceolate, 30–50 cm. in length, 6.0–8.5 cm. in breadth, coriaceous, finely striated when old, cryptostomata wanting, margin entire, splitting in the older part of the blade obliquely to the midrib; base of blade acute, tip narrowed above, pinnately cleft and generally roughly worn away. Stipe 4–8 cm. in length, cylindrical at the base, terete or compressed above, measuring 4–6 mm. in breadth, and more or less narrowed at the transition point, lower half of the length naked, upper half bearing the sporophylls. Midrib smooth, complanated, 5–8 mm. in breadth, elevated above the blade equally on both surfaces with roundish edges, continuous to the stipe below. Sporophylls metasoric, numerous, often 40 or more, obliquely pinnately arranged on both margins of the stipe, a few lower ones at wide intervals, but middle and upper ones approximate and regularly disposed, adding new ones successively upwards, long-cuneate, 6–12 cm. long, 7–25 mm. broad, with more or less well-defined petiole; base of sporophyll tapering or obtuse, generally asymmetrical; tip obtuse or truncate, generally irregularly dentated. Sorus, on both surfaces of each sporophyll, in a continuous patch occupying the lower half of the surface with obscure and fading boundary.

*Remarks on the species.* The present species has a well-marked character making it readily distinguishable from the others. The sporophylls are always attenuated towards the base to form comparatively long petioles, the lower side being more developed than the upper, resulting in an oblique ascending base. This

unique peculiarity has been passed over by SCHRADER. The resemblance of the species to *A. praelonga* KJELLM. is in the texture of the blade and in the mode of the midrib, on which, however, much specific importance should not be laid. The older part of the blade is finely striated in the same manner as in *A. marginata*.

*Locality.* Port San Juan, Vancouver Island (SCHRADER) ; Lands End, San Francisco (SETCHELL).

*Alaria grandifolia* J. AG.

(Plate XIV.)

Grönlands Lam. och Fuc., p. 26.—KJELLM.: Spetzberg. Thall. II, p. 10.—Id.: Alg. Arct. Sea, p. 217.—Id.: Algenveg. Murm. Meeres, p. 35.—FOSLIE: Mar. Alg. Norway, I, p. 73.

= *Alaria membranacea* J. AG.: (Specimina Spitzbergenses partim).

= *Alaria membranacea* KJELLM.: Alg. Arct. Sea, p. 215.

= *Alaria membranacea* FOSLIE: Mar. Alg. Norway, I, p. 72 (excl. synonym.).

= *Alaria Pylaii* var. *grandifolia* JÖNSS.: Mar. Alg. East Greenl., p. 21.—ROSENV.: Mar. Alg. N. E. Greenl., p. 112, fig. 5.

= *Alaria Pylaii*  $\beta$  *membranacea* JÖNSS.: Mar. Alg. East. Greenl. p. 21.—Id.: Mar. Alg. Jan Mayen, p. 306.

= *Alaria oblonga* KJELLM.: Alg. Arct. Sea, p. 220, Pl. 25, fig. 21-24.

? = *Alaria esculenta* EATON: List, p. 44 (sec. J. AGARDH).

? = *Laminaria esculenta* LINDL.: Bot. Not., p. 157 (sec. J. AGARDH).

*Definition of the species.* Root, holdfast of dendritic ramification. Blade linear, a few or perhaps several meters in length, 20-30 cm.\* in breadth, coriaceous, cryptostomata wanting(?), margin entire, undulating, splitting in the older part of the blade obliquely to the midrib; base of blade acute, often tapering. Stipe up to 125 cm.\* in length, cylindrical below, up to 2 cm.\* in diameter,



gradually broadened and terete or ancipitous upwards, 2–3 cm.\* in width, quickly narrowed at the transition point, lower half of the length naked, upper half bearing the sporophylls. Midrib smooth, terete, elevated above the blade equally on both surfaces with roundish edges. Sporophylls metasoric, numerous, pinnately arranged on both margins of the anticipitous region of the stipe, some lowermost at wide intervals (6–10 mm.\*), but middle and upper ones approximate, adding new ones successively upwards, linear-cuneate, 30–60 cm.\* in length, 3–7 cm.\* in breadth, tapering gently downwards into cylindrical petioles; tip of sporophyll obtuse or roundish; margin undulating plicate. Sorus in a continuous patch, on both surfaces of each sporophyll, occupying lower half area of the surface except a narrow border along the margin, and fading downwards near the base of the sporophyll.

*Remarks on the synonyms.* This is the second largest *Alaria* hitherto known. It is specifically described as attaining an enormous size in every part, to such extent as has never hitherto been reported of other allied species. In Spetzbergens Thallophter, II, p. 10, KJELLMAN reports the largest specimen he has measured:—stipe, 125 cm. long, 2 cm. in diameter, blade over 100 cm. long, 30 cm. broad, sporophylls 60 cm. long, 7 cm. broad. The largest specimen of *A. grandifolia* in the Agardhian Herbarium at Lund has the stipe much shorter, but in other parts nearly the same measurement.

The original specimens of the present species at Lund are not many in number so that we are unable to trace all modifications of fronds according to the age of the plant. Specimen No. 2256, which is called forma *adulta* by J. AGARDH, is the most complete one among the set. It has a certain resemblance to a fully grown form of *A. macroptera*, but its sporophylls are long linear, tapering downwards, and the blade is not corrugated in the way

peculiar to the latter (Plate XIV). Comparing the original with *A. oblonga* KJELLM., and judging from observations on the North Pacific species, I am strongly inclined to believe that the latter may represent a young stage of the present plant. The differences between them are merely in substance of blade and size of frond, which can never be considered specific. In the Agardhian Herbarium, co-types of *A. oblonga* KJELLM. and *A. macroptera* (RUPR.) are joined together under the species cover of the latter. But, as above stated, the typical form of *A. macroptera* (RUPR.) is easily separated from *A. oblonga* KJELLM., and eventually from the present. It is not to be denied that RUPRECHT has distributed under *Phasganon macropterum* RUPR. many specimens not specifically uniform. Its co-type in Trinity College, Dublin, is more referable to *A. dolichorhachis* KJELLM. than to any other.

JÖNSSON identified some specimens from the east coast of Greenland with the present species but mentioned them as a variety of *A. Pylaii* J. AG. The limitation taken by him for the latter species is the same as by ROSENVENGE in Grönlands Havalger, p. 838; hence, not exactly agreeing with GREVILLE or J. AGARDH. ROSENVENGE naturally followed the view in arranging his specimens from the north-east coast of the same land. The identifications by the two botanists appear to be quite correct, but to bring *A. grandifolia* J. AG. down to a variety of *A. Pylaii* GREV. seems to be open to criticism. The limits of the varieties or the forms of *A. Pylaii* have so far not been very clear. Yet I can not readily acknowledge that the form within the specific conception of the present species may be directly related with that of *A. Pylaii* GREV. A discussion on this matter is a discussion on the specific definition of *A. Pylaii* GREV.

The same writer also mentions *A. Pylaii*  $\beta$  *membranacea*

ROSENV. as having been collected in the same region. He remarks the variety to be "so closely connected with *A. grandifolia* J. AG. that according to our present knowledge of these forms they can not be said to differ in anything, but their size." If he mentions in a varietal rank a specimen which differed in nothing but the size, it is in our conception naturally to be identified with the type. KJELLMAN has also emphatically stated that the young individuals of *A. grandifolia* collected in Spitzbergen all agree with *A. membranacea* J. AG. Cfr. Spetzbergens Thallopkyter, II, p. 12. Some of the original specimens of the latter at Lund justify the view of JÖNSSON and KJELLMAN, but some of them, especially those from Greenland, appear to me hardly distinct from *A. Pylaii* GREV. The specimens treated by KJELLMAN as *A. membranacea* in Algæ Arct. Sea, p. 215, are to be brought under the present species.

*Locality.* Jan Mayen (JÖNSSON): Norwegian coasts; Nord-landen (KJELLMAN), Finmarken (KJELLMAN), Maasö (KJELLMAN), Gjesvær (KJELLMAN), Berlevaag (FOSLIE), Kiberg (FOSLIE), Kjöllefjord (FOSLIE): Spitzbergen; North Gänse Cape (KJELLMAN), South Gänse Cape (KJELLMAN): Siberian Sea; Irkaipi (KJELLMAN): Greenland; Tasiusak (JÖNSSON), Tiningnekelak (JÖNSSON), Nualik (JÖNSSON), Kap Borlase Waren (JÖNSSON), Ikerasak (JÖNSSON), Cape Bismark Peninsula (ROSENVENGE).

### *Alaria angusta* KJELLM.

(Plate XV, fig. 1-4.)

Om Beringhafvets Algflora, p. 33, Tab. 3, fig. 1-4.—DE TONI: Syll. Alg. III, p. 332.

= *Alaria laticosta* KJELLM.: Om Beringhafvets Algflora, p. 40, Tab. 6, fig. 1-3.—DE TONI: Syll. Alg. III, p. 331.

?= *Alaria esculenta* P. et R.: Illustr. Alg., p. 11. *p.p.*

*Definition of the species.* Root, holdfast of hemispherical shape in general outline, with the rhizines at first thick and complanated, and broadened outwards, soon ramifying quickly and irregularly, each final segment terminating in a hapter. Blade linear-lanceolate, 1-2 meters in length, 4-8 cm. in breadth, coriaceous, cryptostomata wanting, margin entire, but splitting obliquely or almost transversely to the midrib in the older part, outer border of segments often subulate and curved upwards; base acute or tapering, not rarely more or less abruptly expanding upwards. Stipe 4-10 cm.\* in length, cylindrical below, 2-5 mm.\* in diameter, terete above, suddenly narrowed at the transition point. Midrib smooth, complanated, 4-6 mm.\* broad but sometimes as broad as 9.5 mm.\* in the dried specimens, prominent above the blade equally on both surfaces with angulate edges. Sporophylls metasoric, numerous, fasciculate, condensed to a broadened short length near the upper end of the stipe, adding new ones upwards as well as between the older ones, long, linear, 6-10-15 mm.\* in breadth, 25-40 cm.\* in length, attenuated towards the base, ending in filiform petioles, round or acute at the apices. Sori gradually fading towards the apex of sporophyll.<sup>1)</sup>

*Remarks on the limit of variation.* The present and the next species have various peculiarities in common, so that one may be taken as a variety of the other. Still, as both are pretty safely separable from each other by the shapes of the sporophylls, I choose to keep them both in specific rank. When yet young, a few sporophylls are produced from the margins of the stipe more or less apart. In such a stage of development, the plant may be taken as a young form of *A. esculenta*, *A. prælonga*, or the like.

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1) The sterile, upper portions of the sporophylls remain in healthy condition for a considerable time. In some specimens the portions are maculated in the manner of shagreen leather.

In the matured forms, however, the sporophylls of this species are found limited to a short length of the stipe near the transition point. The part of the stipe which bears the fasciculate sporophylls is somewhat more broadened than the naked part. New young sporophylls may grow not only successively above the other, but often from a point between the older ones. This mode of localization of the sporophylls should be distinguished from a condensed pinnation in which a large number of the lower sporophylls has dropped owing to age. KJELLMAN, in defining the three species, *A. praelonga*, *A. lanceolata*, and *A. laticosta*, made no distinction in the modes of disposition of the sporophylls and simply diagnosed "sporophyllis numerosissimis, fasciculatis, . . . "

The size of sporophylls and blades, consequently the breadth of the midribs are variable in this species.\* This is perhaps due more to the roughness or salinity of the water than to the age of the plant. KJELLMAN appears to have put too much stress on this sort of variation as to describe individuals of different size in different specific position.

*Remarks on the synonyms.* I propose to combine *A. laticosta* KJELLM. with the present. The former was established from a single specimen cast ashore in the same locality as the latter. By comparing the type specimens of both at Upsala and referring to their descriptions I can not find out any marked difference between them except in the breadths of the midribs. This is by no means of specific importance as can be proved from the specimens at my disposal. In the type specimens of *A. angusta* the midribs vary from 4 mm. to 6 mm. in breadth in the dried state, while the type of *A. laticosta* measures 9.5 mm. KJELLMAN gave the measurements from wet preparations.



SAUNDER'S<sup>1)</sup> has identified a plant from Kukak Bay with *A. laticosta*. He quotes KJELLMAN'S opinion on his specimen which reads; "The form, color and consistency of the blade, and the form, width and rigidity of the sporophyll differ somewhat from this species." I do not understand how SAUNDERS could dare identify his specimen with *A. laticosta* KJELLM. in spite of such an opinion from the author. The points mentioned by KJELLMAN are the important characters for specific distinction, and the breadth of the midrib, on which SAUNDERS seems to have put great stress, is hardly of specific importance as stated above.

There are two specimens of *Alaria*, kept in the herbarium of the Academy of Science of Petrograd under *A. esculenta*, collected by POSTELS in 1849. The locality is given as "Sitka (an St. Paul?)" in RUPRECHT'S handwriting. One of them is a big plant with the blade about 6 feet in length, 3-4 inches in breadth, the base attenuating and the midrib prominent, 3-4 mm. in breadth; the stipe is hardly an inch long, but provided with fasciculate, numerous sporophylls of about a foot in length and one third of an inch in breadth. The other specimen has the sporophylls about an inch in breadth and 5 inches in length. These are undoubtedly the specimens related to in RUPRECHT'S Tange des ochotischen Meeres, p. 360. I could not determine them with accuracy but they seemed to me very likely to be referable to this species or to *A. lanceolata*.

*Locality.* Bering Island (KJELLMAN); ?Sitka (POSTELS); Urup Island and Etorofu Island, South Kuriles (K. MIYABE, Herb. S.A.C.).

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1) SAUNDERS: Harr. Alaska Exped., Alge, p. 425

*Alaria teniata* KJELLM.

(Plate XVI, figs. 1-5.)

Om Beringhafvets Algflora, p. 36, Pl. 7, fig. 1-3.

= *Alaria esculenta angustifolia* P. et R.: Illustr. Alg., p. 11, p.p.

*Definition of the species.* Root, holdfast of hemispherical shape in general outline, with the rhizines at first thick and complanated and broadened outwards, soon ramifying quickly and irregularly, each final segment terminating in a hapter. Blade linear or band-form, attaining to 3.70 meters in length, but measuring 3.5-5.0 cm. in the maximum breadth, coriaceous, cryptostomata wanting, margin entire, splitting obliquely to the midrib in the older parts; base of blade cuneate or attenuate; Stipe 5-6 cm. in length, cylindrical below, 2.5-3.0 mm. in diameter, terete above, and suddenly narrowed at the transition point. Midrib smooth, complanated, 2-3 mm. broad, prominent above the blade on both surfaces with angulate edges, continuous to the stipe below. Sporophylls metasoric, numerous, fasciculate, limited to an abruptly expanded short length near the upper end of the stipe, adding new ones successively upwards as well as between the older ones, linear-lanceolate, attenuated towards the base ending in filiform petioles, acute or tapering at the apices. Sorus occupying a greater part of the surface of sporophyll, leaving a terminal portion and a narrow border along the margin sterile.

*Remarks on the species.* After a close study of the original specimen of *A. teniata* KJELLM. in the Botanical Museum of Upsala I have little doubt of its identity with the Alaskan specimen of *A. esculenta angustifolia* P. et R. in the herbarium of the Academy of Science of Petrograd. The limitation of f. *angustifolia* P. et R.

taken in Illustr. Alg. is quite ambiguous even when we try to draw a definite conception from the original specimens. I choose therefore to take the specific name proposed by KJELLMAN to the present plant. POSTELS and RUPRECHT refer *Laminaria esculenta taniata* DE LA PYL to their forma, but this forma has been referred by many algologists to *A. esculenta* GREV.

KJELLMAN relates (l. c., p. 37) that he collected only one specimen of this species, cast ashore on Bering Island. The species, however, as already supposed by KJELLMAN, seems fairly common in the northwestern Pacific as it is often found along the Kurile Islands as far southwest as Hidaka Province in Hokkaido. As stated by KJELLMAN, the plant, especially when sterile, considerably resembles the Atlantic species *A. esculenta*. The sporophylls, however, are strictly limited to a short length of the stipe, 40–50 sporophylls aggregated within 6–8 mm. on each side. The same writer remarks also that this species stands nearest to *A. fistulosa*. He mentioned the shapes of the midribs as the reason. This, however, appears to me quite opinionate as has been already pointed out on p. 78.

In Fertilizer Resources of the United States, p. 162, SETCHELL has provisionally combined *A. angusta* and *A. crispa* KJELLM. with the present species. As SETCHELL states in it, all these three species have not been seen since the original collection. In our collections the material is ample enough to conclude that *A. taniata* KJELLM. is a good and distinct species. It stands quite near the preceding species as already stated, but the present plant has invariably small sporophylls of lanceolate shape with acute or tapering apex.

*Locality.* Bering Island (KJELLMAN); Kushiro Province (K. WADA, Herb. S.A.C.), Hidaka Province (K. MIYABE, Herb. S.A.C.), Hokkaido.

*Alaria lanceolata* KJELLM.

(Plate XVII, figs. 1-3.)

Om Beringhafvets Algflora, p. 39, Tab. 5, fig. 1-3.—DE TONI: Syll. Alg. III, p. 331.

?=*Alaria lanceolata* SAUNDERS: Harr. Alaska Exped., Alage, p. 426, Pl. LIII.

?=*Alaria dolichorhachis* SETCH.: in COLL., HOLDEN and SETCH.: Phyc. Bor.-Amer., No. XII.

*Definition of the species.* Root, holdfast of dendritic ramification. Blade linear-lanceolate, 1-2 meters in length, coriaceous-membranaceous, with cryptostomata except in lower portion, margin entire, more or less undulately plicated, base cuneate. Stipe very short, hardly a few centimeters in length, subterete. Midrib smooth, complanated, 4-7 mm. broad, slightly prominent. Sporophylls metasoric, numerous, limited to a short length of the stipe, but distinct, linear-cuneate or cuneate-spathulate, 6-10-15 mm. in breadth, 12-20 cm. in length, subcoriaceous. Sorus on both surfaces of each sporophyll in a continuous patch, generally occupying a greater part of the surface, leaving a terminal portion and a narrow border along the margin sterile.

*Remarks on the affinity to other species.* This has been a rather incompletely defined species. SAUNDERS, SETCHELL, COLLINS, etc., reported the present species from the northwest coasts of North America. I am, however, of the opinion that the specimens which they have determined as this may be more safely referred to other species, such as *A. praelonga* KJELLM., *A. marginata* R. et R., or *A. dolichorhachis* KJELLM.

The present species has some resemblance to *A. angusta* KJELLM., *A. teniata* KJELLM. and *A. praelonga* KJELLM. It can be

distinguished from them by the presence of cryptostomata in the blade. In some specimens, however, they are often absent in a lower portion, and in some old ones they remain simply a brownish dots on the blade, losing all the hairs from the very base. Thus the distinguishing character is frequently unreliable. In such case it may be separated from the former two species by the holdfast, and from the last one by the sporophylls.

The illustration of *Alaria* delineated by SAUNDERS as Harr. Alaska Exped., Algæ, Plate LIII, under *A. laticosta*, is rather embarrassing for positive determination. He does not give its full description but simply remarks that his determination was after receiving KJELLMAN's opinion on one of his specimens and that it is easily recognized by the tufts of "long cryptostomata" richly frosted on the surface of the blade. The type specimen of *A. lanceolata* KJELLM. has cryptostomata but not in such a way as to count as a specific peculiarity; and the density of cryptostomata is never of specific importance. The species is diagnosed to have the sporophylls fasciculate and the type specimen shows this character very well. The illustration by SAUNDERS clearly shows that they are condensed but pinnately arranged. In general appearance of frond, SAUNDERS's plant resembles *A. elliptica* to a certain extent. I have not noticed any cryptostoma in the co-type of *A. elliptica* at Lund, and nothing is stated by KJELLMAN relating to this point.

*Locality.* Sitcha Harbour (SAUNDERS); Glacier Bay (SAUNDERS); Bering Island (KJELLMAN); North Kuriles(!).



**Species Doubtful.*****Laminaria muscefolia* DE LA PYL.**

Flora Terre Neuve, p. 31.

I have not seen any reliable authentic specimen of this species. In the Agardhian Herbarium at Lund there is a fragment of *Alaria* collected in Newfoundland and sent from DE LA PYL under *Laminaria muscefolia*. It is a part of the blade, cut off on both ends, without sporophyll or any other part which shows the specific characters.

In Grönlands Lam. och Fucaceer, p. 23, J. AGARDH refers to the descriptions of *Alaria* by various former writers under *Alaria muscefolia* J. AG., but mostly with ample doubts. Judging from the specimens in the Agardhian Herbarium, J. AGARDH's specific conception of *A. muscefolia* J. AG. seems to be very uncertain. Several of them from the Atlantic coast of North America appear to be satisfactorily identified with *A. Pylaii* GREV. and one from Spitzbergen is, in my opinion, to be determined as *A. dolichorhachis* KJELLM.

In Fertilizer Resources of the United States, p. 163, SETCHELL mentions *A. muscefolia* J. AG. in an independent specific rank and assigns it to the Atlantic coast of North America, from Newfoundland to Maine. This may perhaps mean a form which is treated in the present Monograph under *A. Pylaii* GREV.

In Spetzbergens Thallopkyter, II, p. 12, KJELLMAN remarks:—"Mellan *A. esculenta* och *muscefolia* är skillnaden icke betydlig." This is probably the ground on which he reduced *Laminaria muscefolia* DE LA PYL to a forma of *A. esculenta* GREV. But what he understood by *L. muscefolia* is not very clear to me. The type

of *A. esculenta* f. *muscefolia* KJELLM., Algæ Arctic Sea, p. 212, is a typical form of *A. esculenta* GREV. He also mentions the species in the list of algæ from Nova Zembla. Cfr. Algenveg. Murman. Meeres, p. 35. He regarded it as a northern form of *A. esculenta* (Algæ Arctic Sea, p. 213).

I am inclined to suppose that DE LA PYL meant by *Laminaria muscefolia* those individuals of *Alaria* which have the blades transversely cleft so as to resemble a *Musa* leaf, and by *Laminaria esculenta* var. *platyphylla* those which have blades still young and plain, without placing much importance on the other characters.

*Alaria Delisii* GREV.

Alg. Brit. Synop., p. 39.

= *Agarum Delisii* BORY: in Diet. Class., IX, p. 194.

= *Orgyia Delisii* TREVISAN: Nomencl. Alg., p. 28.

This species has been established on the material brought to Europe by DELISE from Newfoundland. I did not see any authentic specimen. RUPRECHT doubts the species, thinking it referable to *Laminaria esculenta* var. *remotifolia* DE LA PYL. Cfr. Tange des ochotischen Meeres, p. 364.

*Alaria linearis* STRÖMF.

Alg. Island. Kust., p. 38, Tab. II, fig. 2-3.

*Alaria flagellaris* STRÖMF.

Alg. Island. Kust., p. 42, Tab. II, fig. 4-6.

These two species described by STRÖMFELT are not satisfactorily known to me. The most important and distinguishing characters

of these species seem to lie, as proposed by STRÖMFELT, in the shape of cross section of the midrib. RUPRECHT has also taken a similar point as an important character in discussing *Fucus tetragonus* and *Fucus teres*, comparing them with *A. esculenta* P. et R. BÖRGESSEN too, used this character in distinguishing his Færøese specimens into *A. esculenta* GREV. and *A. Pylaii* GREV. What systematic value the rectangular or ancipituous shape of the cross sections of the midrib may have is very doubtful to me. BÖRGESSEN notes that young specimens of *A. esculenta* "often have a midrib which must most properly be called two-edged." This fact induces me to suppose, as well as the fact that *A. flagellaris* is known in a sterile stage only, that the two species described by STRÖMFELT are really only one species and also that they may be local forms of *A. esculenta* GREV. It appears almost safe to bring *A. linearis* STRÖMF. down to a synonym of *A. esculenta* GREV. There still remains a question about *A. flagellaris*. It may be regarded as a younger form of *A. esculenta* GREV., or referable to *A. Pylaii* GREV., or a distinct form or species.

It is to be noted that there are two distinct forms of the cross sections of the midribs of the Atlantic forms of *Alaria* which are passing under *A. esculenta* GREV. One is decidedly rectangular and has a well marked spanning cortex and thick medullary sheath, and the cartilaginous content in the sieve cells is highly developed. The other is elliptical or ancipitous elliptical in the shape, the medullary sheath slightly broader than in the remaining part, the spanning cortex limited to the crucial point and the cartilaginous content of the trumpet hyphæ, so far as I have examined, not recognizable. Experiences teach me that the anatomical differences as here mentioned may not be of much importance in the specific distinctions. Still, these two forms appear to me

not to be due to the age of the plant, as they have been separable in the well developed and matured specimens. If we follow STRÖMFELT's view, the latter should be referred to *A. flagellaris*.

The material of the Atlantic forms of *Alaria* at my disposal is limited in number and seems by no means to represent every possible form. I think it, therefore, better to leave the point in an unsettled state, for a future investigation by one who may have material enough to command these forms.

ROSENVENGE<sup>1)</sup> determined three specimens from Greenland as *A. flagellaris* STRÖMF. Some of these were sporophyll-bearing. According to the measurements of the plants given by him, the largest sporophyll was 40 cm. in length. He remarks :—" Cette espèce paraît être très voisine de l'*A. Pylaii* et de l'*A. grandifolia* : reste à rechercher, si elle en est bien distincte." This may be understood as assuring that his specimens are not referable to *A. esculenta*. JÖNSSON mentions ROSENVENGE's *A. flagellaris* under *A. esculenta* var. *pinnata* (GUNN.) KJELLM., though without stating the reason for doing so.

To the above discussion, the observations of GOODENOUGH and WOODWARD must be brought into consideration. In TURNER's *Historia Fucorum*, Vol. II, p. 120, it says :—" The excellent authors of observation upon the British Fuci have, in the Linnean Transactions, divided *F. esculentus* into two species, to which they have given the names of *F. teres* and *F. tetragonus* and they have pointed out such striking characters of distinction between them, that, were these only permanent, there could be no question of their being sufficient to establish priority of this separation . . . ." So TURNER related the unseparableness of two such forms. In my opinion, what the two observers have mentioned as the distinc-

1) ROSENVENGE : Deux. Mém. Alg. Mar. Groenland, p. 50.

tions between the two "species" are mostly the differences of the frond according to the age of the plant.

**Species Removed.**

*Alaria amplexicaulis* MARTENS.

Preus. Exped. nach Ost-Asien, Tange, p. 114.

*Alaria pinnatifida* HARVEY.

Character of New Algæ, p. 329.

Both are synonyms of *Undaria pinnatifida* SURINGAR.

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-

## Contents.

	Page.
Introduction .....	1
General Morphology.....	3
Stipe .....	4
Blade .....	11
Midrib .....	15
Sporophyll .....	22
Holdfast .....	27
Cryptostomata .....	28
Mucilage Glands .....	36
Monstrosities of the frond .....	42
Development and Life History of <i>Alaria</i> .....	44
Economic Uses of <i>Alaria</i> .....	58
Distribution and Habitat.....	60
Systematic Position of the Genus <i>Alaria</i> .....	70
Synoptical Key to the Species .....	74
Species .....	76
<i>Alaria fistulosa</i> P. et R. ....	76
<i>A. macroptera</i> (Rupr.) .....	79
<i>A. ochotensis</i> sp. nov. ....	81
<i>A. praelonga</i> Kjellm. ....	86
<i>A. dolichorhachis</i> Kjellm. ....	89
<i>A. marginata</i> P. et R. ....	93
<i>A. Pylaii</i> Grev. ....	97
<i>A. crassifolia</i> Kjellm. ....	105
<i>A. esculenta</i> Grev. ....	108
<i>A. valida</i> Setch. et Kjellm. ....	116
<i>A. nana</i> Schrader. ....	118
<i>A. grandifolia</i> J. Ag. ....	120
<i>A. angusta</i> Kjellm. ....	123
<i>A. tornata</i> Kjellm. ....	127
<i>A. lanceolata</i> Kjellm. ....	129
Species Doubtful .....	131
<i>Laminaria musaeifolia</i> De la Pyl. ....	131
<i>Alaria Delisii</i> Grev. ....	132
<i>A. linearis</i> Strömf. ....	132
<i>A. flagellaris</i> Strömf. ....	132
Species Removed. ....	135
<i>Alaria amplexicaulis</i> Martens. ....	135
<i>A. pinnatifida</i> Harv. ....	135
List of Literature .....	136
Index.....	142

## Index.

(Figures in thick type indicate that the species is treated as special subject on the page cited, and those in italics refer to the page on which the species is mentioned in a synonymous position).

- Agarum Delisii* Bory. . . . . 122.  
     *esculentum* Bory. . . . . 109.  
     *Gmelini* Mert. . . . . 16.  
     *Pylaii* Bory. . . . . 98, 99, 100,  
         101, 102.  
     *Turneri* P. et R. . . . . 16.  
*Alaria amplexicaulis* Mart. . . . . 104.  
     *angusta* Kjellm. . . . . 13, 23, 27, 47,  
         66, 75, 113, **124**, 128.  
     *cordata* Tilden. . . . . 93, 95, 97.  
     *corrugata* Miyabe. . . . . 79, 82.  
     *crassifolia* Kjellm. . . . . 27, 28, 37, 39,  
         46, 48, 52, 60, 66, 75, 78,  
         87, **105** 111.  
     *crispa* Kjellm. . . . . 89, 90, 92, 128.  
     *curtipes* Saunders. . . . . 93, 96, 118.  
     *curtipes* Tilden . . . . . 97, *116*.  
     *Delisii* Grev. . . . . **132**.  
     *dolichorhachis* Kjellm. . . . . 29, 65, 66, 75,  
         85, **89**, 103, 104, 105,  
         122, 129, 131.  
     *dolichorhachis* Setch. . . . . 129.  
     *elliptica* Kjellm. . . . . 89, 90, 91, 101,  
         104, 130.  
     *esculenta* Dickie. . . . . 98.  
     *esculenta* Grev. . . . . 7, 9, 19, 26,  
         28, 37, 40, 43, 44, 49, 50,  
         54, 58, 60, 65, 66, 71, 75,  
         87, 88, 90, 91, 96, 99, 100,  
         101, 106, **108**, 111, 112,  
         113, 114, 115, 124, 128,  
         132, 133.  
         *f. australis* Kjellm. . . . . 109, 110.  
         *f. fasciculata* Ström. . . . . 109, 110, 111.  
         *f. muscifolia* Kjellm. . . . . 103, 109, 110,  
                 115, 132.  
         *f. pinnata* Börges. . . . . 110.  
         *f. pinnata* Foslie. . . . . 109.  
         *f. typica* Börges. . . . . 109, 110.  
         *f. typica* Kjellm. . . . . 90.  
*Alaria esculenta* Grev. var. *latifolia*  
     Farl. . . . . 98, 104, 110.  
     var. *pinnata* Kjellm. . . . . 90, 134.  
     *esculenta* Harv. . . . . 51, 69, 89, 93,  
         109, 115.  
     *esculenta* P. et R. . . . . 86, 88, 99, 114,  
         123, 126, 133.  
         *a. angustifolia* P. et R. . . . . 110, 127, 127.  
         *β. latifolia* P. et R. . . . . 79, 83, 110,  
                 115.  
         *f. singularis* Rupr. . . . . 89, 92.  
         *γ. pinnatifida* P. et R. . . . . 79, 85, 110,  
                 111.  
     *fistulosa* P. et R. . . . . 10, 12, 20, 21,  
         22, 39, 40, 41, 50, 59, 65,  
         66, 70, 74, **76**, 78, 99,  
         112, 128.  
         *f. platyphylla* Setch. . . . . 40, 77.  
         *f. stenophylla* Setch. . . . . 40, 77.  
     *flagellaris* Ström. . . . . 21, 111, **132**.  
     *flagellaris* Rosenv. . . . . 116.  
     *fragilis et forma.* . . . . 98, 104.  
     *grandifolia* J. Ag. . . . . 21, 28, 50, 52,  
         55, 65, 66, 69, 75, 83, 100,  
         102, 104, 112, 117, **120**,  
         134.  
         *f. adula* J. Ag. . . . . 117.  
         *f. intermedia* J. Ag. . . . . 117.  
         *f. junior* J. Ag. . . . . 117.  
     *grandifolia* Collins. . . . . 116, 117.  
     *lanceolata* Coll., Hold. et  
         Setch. . . . . 59, 86, 93, 96.  
     *lanceolata* Kjellm. . . . . 42, 66, 75, 85,  
         125, 126, **129**.  
     *lanceolata* Saunders. . . . . 129.  
     *laticosta* Kjellm. . . . . 85, 95, 96, 123,  
         125.  
     *laticosta* Saunders. . . . . 79, 84, 130.  
     *linearis* Ström. . . . . 21, 111, **132**.  
     *macrophylla* Miyabe. . . . . 79.

- Alaria macroptera* (Rupr.) . . . 12, 66, 74, **79**,  
83, 85.  
    *marginata* P. et R. . . . 28, 60, 66, 75,  
88, **93**, 95, 96, 99, 112,  
117, 118, 120, 129.  
        *β. musaeformis* P. et R. . . 76, 78.  
        *f. nana* Collins. . . . 119.  
    *marginata* P. et R? . . . 79.  
    *membranacea* J. Ag. . . 90, 98, 102,  
103, 104, 120, 123.  
    *membranacea* Foslie. . . 120.  
    *membranacea* Kjellm. . . 120, 123.  
    *musaeformis* J. Ag. . . . 89, 90, 98, 103,  
104, 113, 115, 131, 132.  
    *musaeformis* Kjellm. . . . 109.  
    *nana* Schrader. . . . 24, 27, 66, 75,  
**118**.  
    *oblonga* Kjellm. . . . 100, 101, 122.  
    *ochotensis* Yendo. . . . 11, 41, 66, 75,  
83, **84**.  
    *pinnatifida* Harv. . . . **135**.  
    *praelonga* Kjellm. . . . 27, 28, 36, 42,  
51, 59, 66, 75, 81, 83, **86**,  
87, 88, 91, 96, 97, 100,  
107, 113, 118, 120, 124,  
125, 129.  
    *praelonga* Setch. et Gard. . . 93.  
        *f. nana* Setch. . . . 119.  
    *Pylaii* J. Ag. . . . 89, 91, 101,  
122.  
        *α. typica* Rosenv. . . . 98.  
        *β. membranacea* Jönssen 120.  
        *β. membranacea* Rosenv. 98, 120.  
        *var. grandifolia* Jönssen 120.  
    *Pylaii* Grev. . . . 10, 14, 21, 60,  
64, 65, 66, 69, 75, 83, 85,  
90, 91, 95, **97**, 110, 122,  
123, 131, 133, 134.  
    *striata* J. Ag. . . . 93, 96.  
    *taeniata* Kjellm. . . . 12, 27, 28, 42,  
66, 75, 78, **127**.  
    *tennifolia* Setch. . . . 98, 103.  
        *f. amplior* Setch. . . . 98, 103.  
        *f. typica* Setch. . . . 98, 103.  
    *valida* Setch. et Kjellm. . . 21, 49, 50, 59,  
66, 75, 97, 113, **116**.  
        *f. longipes* Setch. et Gard. 116.  
    *yessoensis* Miyabe. . . . 86.  
    *sp.* Kjellm. . . . 76.
- Ceramium esculentum* Stackh. . . 108.  
*Cymathere triplicata* J. Ag. . . 96, 115.  
*Fucus alatus* Cargill. . . . 113.  
    *esculentus* L. . . . 49, 70, 71, 108,  
112, 134.  
    *esculentus* Lightf. . . . 108.  
    *fimbriatus* Gmelin. . . . 115.  
*Fucus pinnatus* Gunn. . . . 71, 108, 110,  
113, 114.  
    *teres* Good. et Woodw. . . 71, 108, 133,  
134.  
    *tetragonis* Good. et Woodw. 108, 133, 134.  
*Homocostroma latifolium* J. Ag. . 30.  
*Hirrome undarioides* Yendo. . . 15, 37, 73.  
*Laminaria angustata* Kjellm. . . 41, 59, 108.  
    *Despreauxii* Bory. . . . 98, 102.  
    *digitata* Lamx. . . . 42, 45, 46, 56.  
    *esculenta* Lamx. . . . 109.  
        *var. platyphylla* De  
        la Pyl. . . . 132.  
        *var. remotifolia* De  
        la Pyl. . . . 98, 132.  
        *var. taeniata* De la  
        Pyl. . . . 109, 128.  
    *esculenta* Lindl. . . . 120.  
        *var. Noltii* Hornem. 109.  
    *hyperborea* Lamx. . . . 56.  
    *japonica* Aresch. . . . 56.  
    *linearis* De la Pyl. . . . 109.  
    *longissima* Miyabe. . . . 56, 108.  
    *musaeformis* De la Pyl. 91, 102, 103,  
110, 115, **131**.  
    *Noltii* Ag. . . . 51, 109.  
    *ochotensis* Miyabe. . . . 56.  
    *Peterseniana* Kjellm. . . 16, 36, 73  
    *Pylaii* Bory. . . . 101.  
    *Pylaii* De la Pyl. . . . 83, 98, 100,  
101.  
    *radicosa* Kjellm. . . . 45, 74.  
    *saccharina* Lamx. . . . 42, 45, 56.  
*Musaeformis esculenta* Stackh. . . 108.  
*Orgyia Delisii* Trev. . . . 132.  
    *esculenta* Stackh. . . . 108.  
    *pinnata* Gobi. . . . 71, 78, 114.  
*Phaeoglossum alatum* Rupr. . . . 71, 86, 111,  
112, 113, 114.  
    *var. latifolium* Rupr. 79, 83, 86, 88.  
    *var. macropterum*  
    Rupr. . . . 83.

<i>Phragmon esculentum</i> Gray. . . 108.	<i>Seytosiphon pygmaeus</i> . . . 31.
<i>fistulosum</i> Rupr. . . 76.	<i>Stilophora rhizoides</i> J. Ag. . . 31.
<i>longipes</i> Rupr. . . 79, 82.	<i>Thalassiophyllum clathrus</i> P. et R. 114.
<i>macropterum</i> Rupr. . . 79, 82, 101,	<i>Ulopterix pinnatifida</i> Kjellm. . . 40.
122.	<i>Undaria pinnatifida</i> Sur. . . 15, 37, 39, 40,
<i>marginatum</i> Rupr. . . 88, 93.	41, 45, 48, 135.
<i>Pleurophyceus Gardineri</i> Setch. . . 96.	<i>f. distans</i> Miy. et Okam. 73.
<i>Pterygophora californica</i> . . . 16.	<i>f. narutensis</i> Yendo. . . 73.
<i>Rhodymenia palmata</i> Grev. . . 58.	<i>f. typica</i> Yendo. . . 73.
<i>Sargassum filipendula</i> Ag. . . 29.	





K. Yendo:

A Monograph of the Genus *Alaria*.

Plate I.

## Plate I.

*Alaria fistulosa* POST. et RUPP.

- Fig. 1. Basal parts of two matured plants to show the sporophyll-bearing stipe and the holdfasts.  $\times \frac{1}{2}$ .  
Fig. 2. A matured sporophyll in natural size.  
Fig. 3. A part of the blade of a comparatively young plant.  $\times \frac{1}{2}$ .  
Fig. 4. Cross section of the midrib.  $\times 3$ .

(Figs. 1-3 after MIYABE with a little modification).



K. Yendo. *Alaria fistulosa* Post. et Rupr.





K. Yendo:

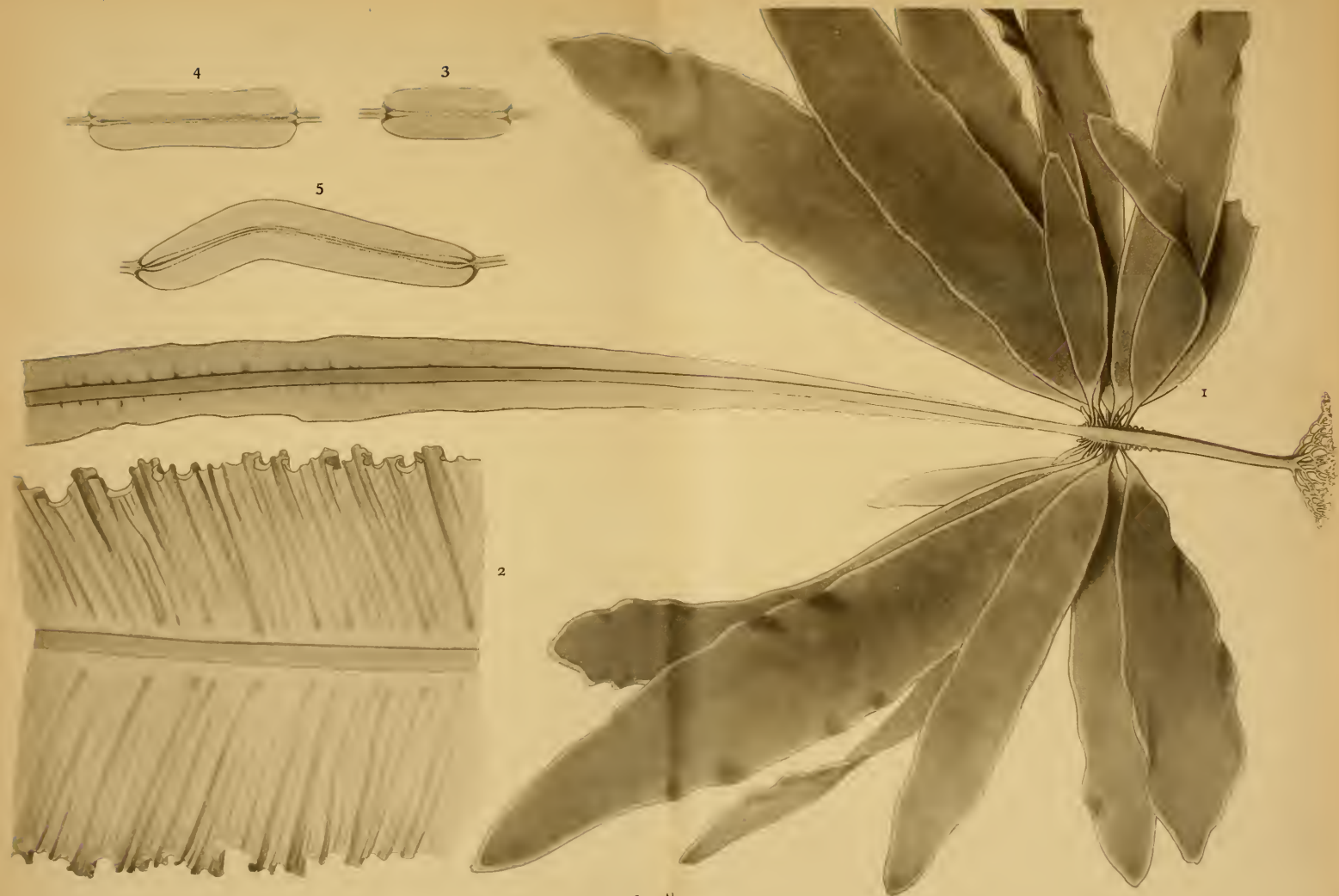
A Monograph of the Genus *Alaria*.

Plate II.

## Plate II.

### *Alaria macroptera* (RUPR.)

- Fig. 1. A second-year frond in natural size, with fully matured sporophylls ; the upper part of the blade cut off.
- Fig. 2. An upper portion of the blade to show the fine corrugation of the margins. Nat. size.
- Figs. 3-5. Cross sections of the midribs of various specimens.  $\times 5$ . In the section shown as Fig. 3 the medulla and the perimedullary tissue have not been so distinct as in the others under the low power lense ; in the medulla the callus formation was especially rich. The midrib shown as Fig. 5 is abnormal in shape as well as in the distribution of the spanning cortices on both margins. The shape of the cross section recalls the figure illustrated by SETCHELL for *Alaria valida*.



K. Yendo. *Maria macroptera* (Rupr.)



K. Yendo:

A Monograph of the Genus *Alania*.

Plate III.



**Plate III.**

*Alaria ochotensis* sp. nov.

Fig. 1. Plant in natural size, with the upper part of the blade cut off.

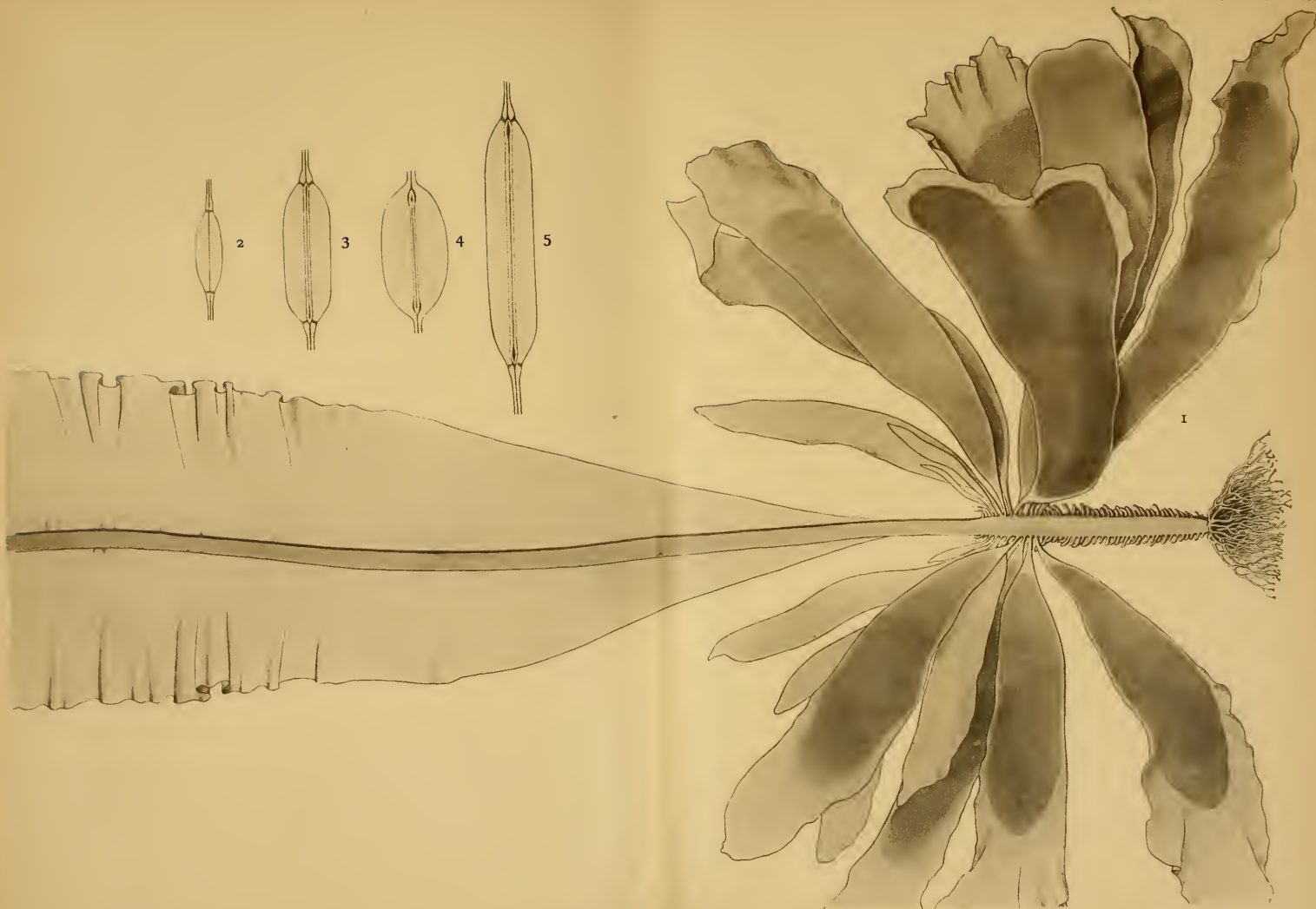
Fig. 2. Cross section of the midrib of a young frond from Jintaki, Sakhalin.  $\times 5$ .

Fig. 3. Cross section of an upper part of the midrib of a matured frond from Aniwa Bay.  $\times 5$ .

Fig. 4. Cross section of a lower part of the midrib of the same frond.  $\times 5$ .

This is to show an example that the shape of the cross sections of the midrib varies even in one and the same individual.

Fig. 5. Cross section of the midrib of a matured frond from Sorenuiya, Sakhalin.  $\times 5$ .



K. Yendo. *Alaria ochotensis*, sp. nov.



K. Yendo :  
A Monograph of the Genus *Alaria*.

Plate IV.

**Plate IV.**

*Alaria praelonga* KJELLM.

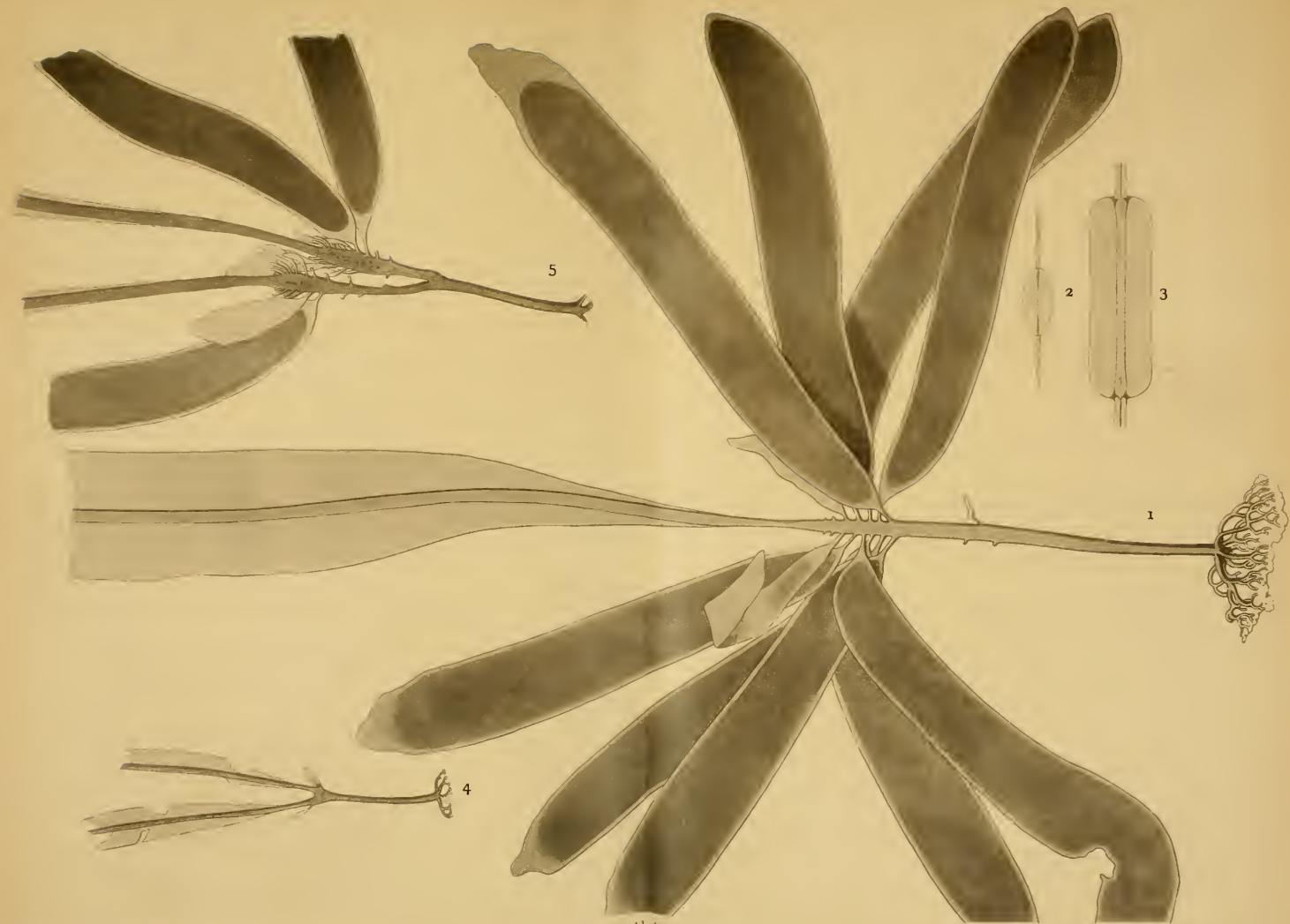
Fig. 1. Frond in natural size, the upper part of the blade cut off.

Fig. 2. Cross section of the midrib of a young frond.  $\times 5$ .

Fig. 3. Cross section of the midrib of a matured frond.  $\times 5$ .

Figs. 4-5. Two examples of branched stipes. Nat. size.





K. Yendo. *Alaria praelonga* Kjellm.



K. Yendo:

A Monograph of the Genus *Alaria*.

Plate V.

**Plate V.**

*Alaria dolichorhachis* KJELLM.

A young specimen of the plant in natural size. After KJELLMAN.



K. Yendo. *Alaria delichothachis* Kjellm.





K. Yendo:

A Monograph of the Genus *Alaria*.

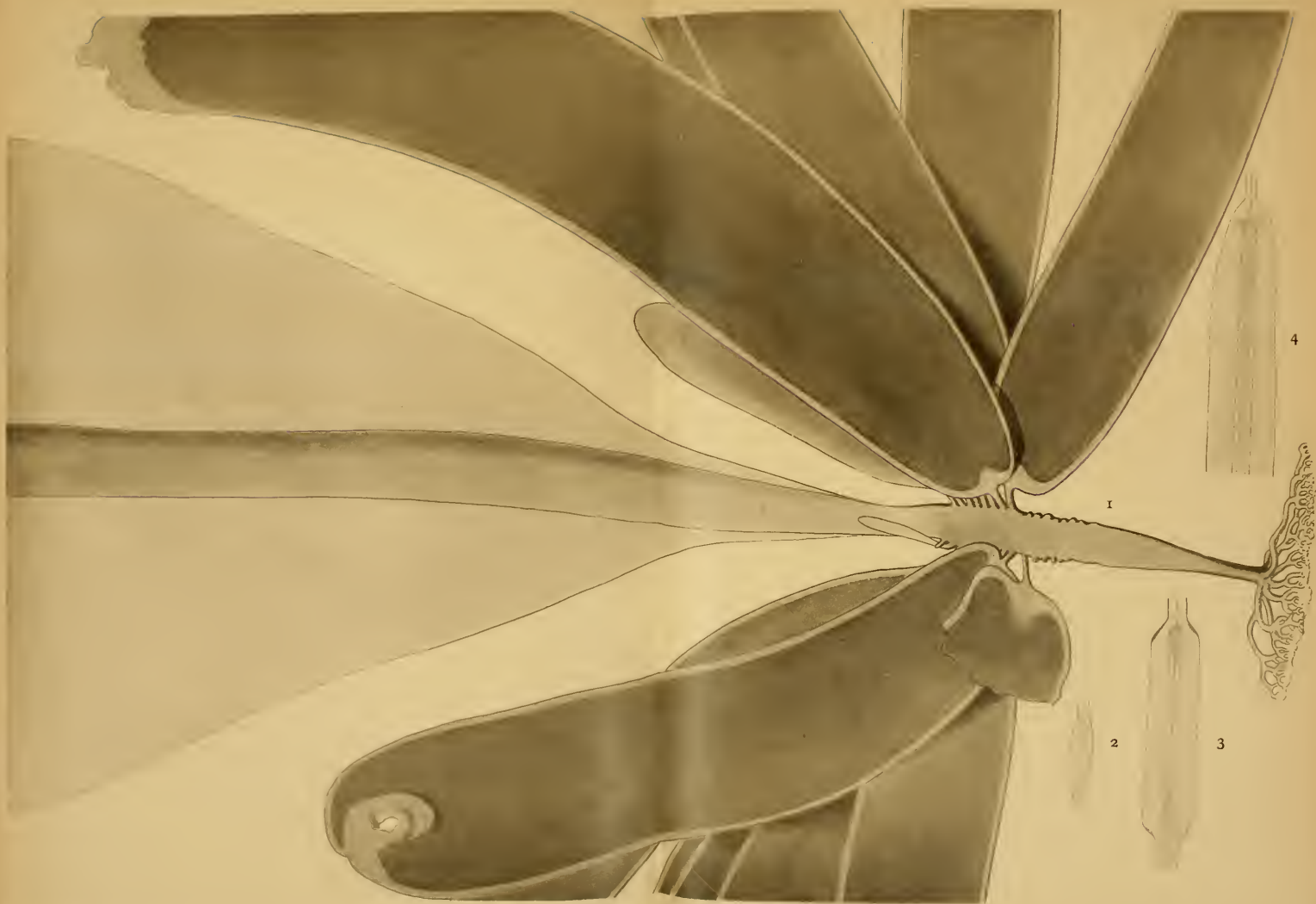
Plate VI

## Plate VI.

*Alaria marginata* Post. et Rupr.

Fig. 1. Basal part of a fully matured plant. Nat. size.

Figs. 2-4. Cross sections of the midribs of a young, half-matured, and a fully matured plant respectively, the last figure showing one half of the breadth.  $\times 5$ . This species has the spanning cortex poorly differentiated, sometimes not reaching to the epidermis as shown in Fig. 4, and sometimes detached as in Fig. 3. The callus formation has been generally less frequently observed in the marginal swellings of the medulla.



K. Yedno. *Alaria marginata* Post. et Rupr.



K. Yendo:

A Monograph of the Genus *Alaria*.

Plate VII.

**Plate VII.**

*Alaria Pylaii* GREY.

Frond in natural size, with the upper part of the blade cut off.  
The specimen shown has the blade fully developed but the sporophylls yet immature.





K. Yendo. *Alaria Pylaii* Grev.



K. Yendo:

A Monograph of the Genus *Alaria*.

Plate VIII.

## Plate VIII.

"*Alaria Pylaii* GREV."

Fig. 1. Specimen No. 2088 in the Agardhian Herbarium under *Alaria Pylaii* J. Ag. On the specimen sheet there is a note in J. AGARDH's handwriting, reading: "Sukkertoppen, BERGGREN. *Al. Despreauxii* BORY. *L. Pylaii* DELAP. vix BORY. *L. muscifolia* var. *remotifolia* DEL."

Fig. 2. Specimen No. 2094 in the same herbarium, bearing the name *Lamin. Pylaii* BORY in AGARDH's handwriting. The specimen does not show the characteristics of *A. Pylaii* GREV. but appears to me to be young fronds of *A. esculenta* GREV.

From photographs kindly supplied by Prof. O. NORDSTEDT.



I



2





K. Yendo :

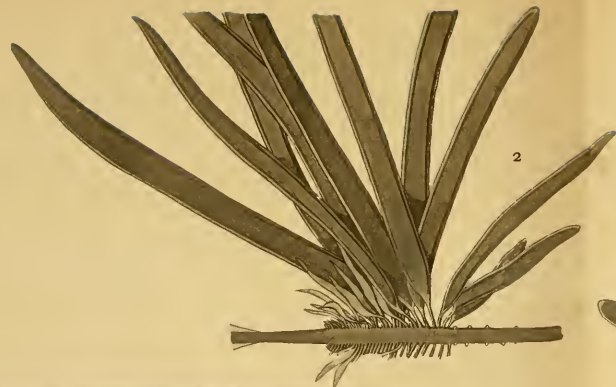
A. Monograph of the Genus *Alaria*.

Plate IX.

**Plate IX.**

*Alaria crassifolia* KJELLM.

- Fig. 1. A fully matured, first-year frond in natural size.
- Fig. 2. Part of the stipe of a fully matured, second-year frond in natural size.
- Fig. 3. A matured sporophyll with the sterile, membranaceous part still attached at the apex. Natural size.



3





K. Yendo :

A Monograph of the Genus *Alaria*.

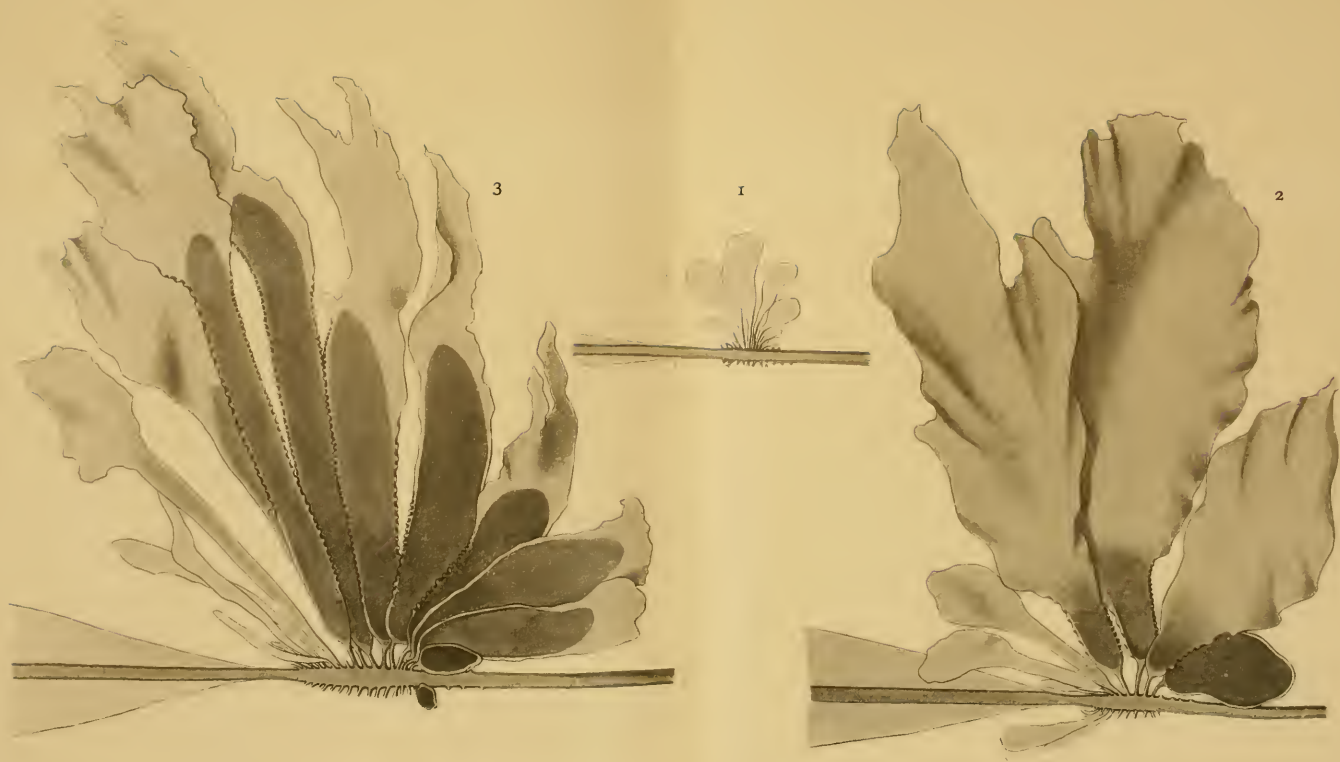
Plate X.

## Plate X.

*Alaria crassifolia* KJELLM.

Figs. 1-3. Various stages of development of the sporophylls of the second-year fronds showing the metasoric morphological change. The first-year sporophylls have mostly dropped off leaving the scars of their attachment points as verrucose processes. Fig. 1, young sporophylls as found at an early part of spring. Fig. 2, a more advanced stage; the basal parts of the sporophylls are markedly thicker and narrower than the sterile upper parts, and the margins are finely crisped. All in natural size.







K. Yendo :

A Monograph of the Genus *Aluria*.

Plate XI.

## Plate XI.

*Alaria esculenta* GREV.

- Fig. 1. Frond in natural size, with the upper part of the blade cut off.  
The metasoric character of the sporophylls is not satisfactorily shown in this figure. The gradual morphological changes of the sporophylls as they become soriferous are essentially similar to those shown in Plate X for *A. crassifolia* KJELLM.
- Fig. 2. Cross section of the midrib of a young plant.  $\times 5$ .
- Fig. 3. Cross section of the midrib of a well-grown plant.  $\times 5$ .



K. Yendo. *Alaria esculenta* Grev.





K. Yendo :

A: Monograph of the Genus: *Alaria*.

Plate XII.

## Plate XII.

*Alaria valida* KJELLM. et SETCH.

Fig. 1. A matured plant in natural size, with the upper part of the blade cut off.

Figs. 2-3. Cross sections of the midribs.  $\times 5$ . The midrib shown in Fig. 3 is dorsi-ventrally assymetrical, and the spanning cortices at the marginal swellings of the medulla are distributed so as more or less to show the abnormality.



K. Yendo. *Alaria valida* Kjelhm. et Setch.



K. Yendo :

A Monograph of the Genus *Alaria*.

Plate XIII.

**Plate XIII.**

*Alaria nana* SCHRADER.

- Fig. 1. A plant in natural size, with the upper part of the blade cut off.  
The specimen here shown is a complete form found in a rather quiet water. The species is habitually found on a surfing reef with the blade roughly torn away, and the holdfast is much less ramified than shown in the figure.
- Fig. 2. Cross section of the midrib of a plant about 22 cm. in total height.  
The spanning cortex not yet differentiated.  $\times 5$ .
- Fig. 3. Cross section of the midrib of a matured plant.  $\times 5$ .





K. Yendo. *Alaria nana* Schrader.



K. Yendo:

A Monograph of the Genus *Alaria*.

Plate XIV.

**Plate XIV.**

*Alaria grandifolia* J. Ag.

One of the type specimens in the Agardhian Herbarium, under f. *adulta* J. Ag. (specimen No. 2256). Photographed by Mr. MATSSON through the kindness of Prof. O. NORDSTEDT at the writer's request. The metasoric character of the sporophylls is satisfactorily shown. Scale in centimeters.



K. Yendo. *Alaria grandifolia* J. Ag.





K. Yendo:

A Monograph of the Genus *Alaria*.

Plate XV.

## Plate XV.

*Alaria angusta* KJELLM.

- Fig. 1. Frond in natural size. A second-year plant with the sporophylls not yet fully matured.
- Fig. 2. An upper part of the blade of a well grown plant. The blade is pinnately cleft with the apices of the segments recurved and subulate.
- Figs. 3-4. Cross sections of the midribs at the middle part of the length of the blades. From the specimens collected in the southern Kuriles.  $\times 5$ .



K. Yendo. *Alaria angusta* Kjellm.



K. Yendo:

A Monograph of the Genus *Alaria*.

Plate XVI.

## Plate XVI.

### *Alaria taniata* KJELLM.

- Fig. 1. Frond in natural size, with the greater part of the length of the blade cut off. The metasoric sporophylls have the soral parts evidently broader than the sterile upper parts.
- Fig. 2. Cross section of the midrib at a point near the apex of the blade which measures in dry specimen 369 cm. in total length and 2 cm. at the broadest part.  $\times 5$ .
- Fig. 3. Cross section of the midrib at a point about 25 cm. above the transition point of the same specimen.  $\times 5$ .
- Fig. 4. Cross section of the midrib of a frond with duplicated semi-blades. In the duplicated side of the midrib the spanning cortices are curved inwards and a tissue similar to them is found at the sinns of the semi-blades. The medullary layers of the latter diverge at the outer end of the marginal swelling of the medulla of the midrib.  $\times 5$ .
- Fig. 5. Cross section of the midrib after KJELLMAN. The tetragonal form could not be found with our specimens.  $\times 6$ .





K. Yendo. *Alaria tennista* Kjellm.



K. Yendo :

A. Monograph of the Genus *Alaria*.

Plate XVII.

## Plate XVII.

*Alaria lanceolata* KJELLM.

Fig. 1. Frond in half natural size.

Fig. 2. Sterile sporophyll. Nat. size.

Fig. 3. Cross section of the midrib.  $\times 6$ .

(All figures after KJELLMAN).

N. B.—The figures can not be said to show the specific character accurately. The specimens in my possession, which I identify with the species, are all too young and can not be shown as to represent the species in a monograph. Hence, the original figures, though far from satisfying, are here taken.



K. Yendo. *Alaria lanceolata* Kjellm.





K. Yendo :

A Monograph of the Genus *Alaria*.

Plate XVIII.

## Plate XVIII.

### *Alaria crassifolia* KJELLM.

- Figs. 1-3. Gametophytes found in nature; simple and sterile, branched and antheridial, and branched and oogonial, respectively.  $\times 450$ .
- Figs. 4-5. Sporelings with unicellular rhizoids.  $\times 450$ .
- Figs. 6-7. Monostromatic embryonal blades to show the cellular arrangement. At the stage shown in Fig. 6 the cells are still disposed in the hyperbolic figure as has been observed in a similar stage of *Costaria Turneri*.  $\times 450$ .
- Figs. 8-11. Mucilage glands observed at a post-embryonal frond of about 15 cm. in total height. Fig. 8, surface view of a marginal part of the frond at about 5 cm. above the transition region. The glands are denser and smaller along the margin, rarer and larger towards the midrib, and finally entirely absent. Beyond the area here delineated no gland could be seen. The glands near the transition region are colourless and granular, those at 3-4 cm. above the transition region and upwards gain darker brownish hue.  $\times 54$ . Fig. 9, A part of the same enlarged. The epidermal cells overlying the glands are seldom disposed radially around a gland.  $\times 450$ . Fig. 10, cross section of the blade at the same point.  $\times 450$ . Fig. 11, surface view of an upper part of the blade with the four glands fused together but still with the septal membranes between them.  $\times 450$ .
- Figs. 12-14. Diagrammatic figures of the cross sections of the basal cylindrical part and the complanated part of the stipe, and the midrib respectively, of a two-year old plant. About  $\times 10$ . *a*, epidermal layer (limiting layer of SETCHELL); *b*, second year cortex; *c*, outer cortex composed of radially disposed cells; *d*, inner cortex composed of larger parenchymatic cells; *e*, perimedullary tissue; *f*, medullary sheath; *g*, medulla; *h*, marginal swelling of the medulla; *k*, spanning cortex.
- Fig. 15. Part of a cross section of the midrib of a matured frond, to show the compact tissue of the medullary sheath about the marginal swelling of the medulla; *e*, perimedullary tissue; *f*, medullary sheath; *d*, inner cortex.  $\times 240$ .
- Fig. 16. Part of a cross section of the midrib of a matured frond, a point about the median line, stained in an aqueous solution of anilin blue. The cell-wall of the inner cortex and the hyphae stain very pale, those of the perimedullary tissue deep blue, and the callus of the trumpet cells in the medulla deepest.  $\times 240$ .
- Fig. 17-18. Two trumpet cells; Fig. 15, thick-walled cells, treated first in sulphuric acid and then in chloriodide of zinc. Fig. 16, callus formation, stained in an aqueous solution of anilin blue.  $\times 450$ .





K. Yendo :

A Monograph of the Genus *Alaria*.

Plate XIX.

## Plate XIX.

Fig. 1-3. *Alaria ochotensis* sp. nov.

Fig. 1. Part of a cross section of the midrib: the parenchymatic tissue on the left side is the innermost part of the inner cortex; the thick-walled, large cells, with the hyphal strands traversing through the intercellular spaces on the right, belong to the perimedullary tissue; interposed between these two parts, a narrow area of the medullary sheath, composed of the fibrous cells.  $\times 240$ .

Fig. 2. Surface view of the blade at an upper part to show the distribution of the mucilage glands in a square millimeter.  $\times 54$ .

Fig. 3. A mucilage gland seen from the surface of frond, through the epidermis. The arrangement of the epidermal cells overlying the gland is more or less disturbed but not under any fixed rule as in *Undaria pinnatifida*: no special pore for the gland is to be seen.  $\times 240$ .

Fig. 4. *Alaria marginata* POST. et RUPR.

Cross section of the midrib showing a marginal swelling of the medulla and right half of the thickness of the midrib. In this species the perimedullary tissue and the medullary sheath are slightly differentiated; the spanning cortex is also poorly developed in comparison with the other species.  $\times 240$ .

Figs. 5-12. *Homonostroma latifolium* J. Ag.

Fig. 5. Rhizoidal part of a young plant with embryonal shoots starting from it. About  $\times 50$ . Somewhat diagrammatic.

Fig. 6. Embryonal shoot of a single row of cells.  $\times 240$ .

Fig. 7. The same; a more advanced stage. The cells in the upper part of frond are broader than height. The apical hair begins to appear.  $\times 240$ .

Fig. 8. The same; still more advanced stage. The cells in the middle and upper part of frond are divided longitudinally and transversely to form the monostromatic blade. The apical hair is elongated and septated.  $\times 240$ .

Fig. 9. A young monostromatic frond, with apical hair completed. The marginal hairs are issued pairwise from the upper corners of "segments." Each "segment" is one cell-areole initiated from a mother cell.  $\times 240$ .

Fig. 10. A part of margin of a blade of about 3 mm. in length; young hairs starting from the intervals of the older ones as the blade increases in length by cell-multiplication.  $\times 240$ .

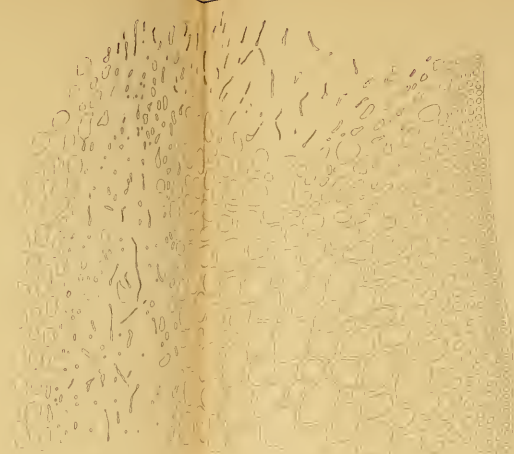
Fig. 11. Cross section of a frond which began to be distromatic.  $\times 240$ .

Fig. 12. Surface view of the blade to show the starting of a hair-tuft; the epidermal cells are divided into much smaller ones which initiate the hairs. The hair-initiating cells are richer in chromoplasts than the ordinary epidermal cells.  $\times 450$ .

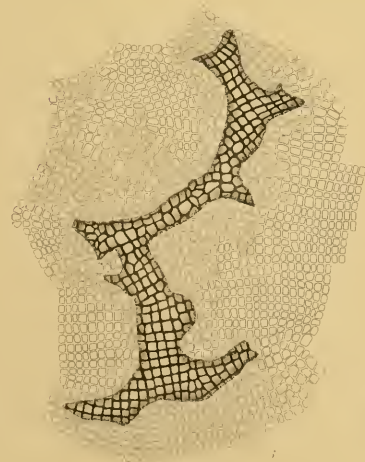




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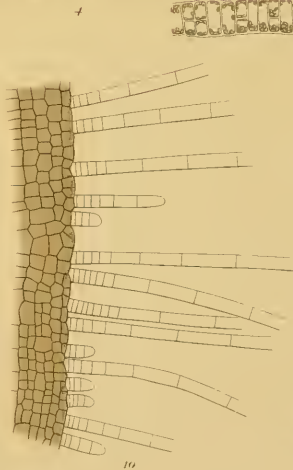
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## Untersuchungen über die Wasseraufnahme bei abgeschnittenen Zweigen.

Von

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Mit 2 Textfiguren.

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### I. Einleitung.

Die Wasseraufnahme abgeschnittener Zweige und die Beeinflussung derselben durch verschiedene Faktoren, sind im Anschluss an Transpirations- und Wasserleitungsprobleme mehrfach untersucht worden.

Z. B. wurde die Einwirkung verschiedener Chemikalien wie Säuren, Alkalien, Salze, usw. auf die Transpiration, von SACHS (11), (12), SENEBIER (14), RICÔME (10), BURGERSTEIN (2), (3) und vielen anderen (5) untersucht, und wir können ersehen, dass im allgemeinen verdünnte Säuren, im Gegensatz zu Alkalien, die Transpiration erhöhen, und ferner, dass verschiedene Salzlösungen, je nach den Eigenschaften der Ionen und nach der Konzentration der Lösungen, verschiedenartige Wirkungen ausüben.

Was die Wasserleitung anbetrifft, so beobachtete STRASBURGER (15) das Aufsteigen von Flüssigkeiten in verkohlten Pflanzenteilen. BÖHM (1) untersuchte auch bei *Phaseolus* die Leitungsfähigkeit

abgestorbener Pflanzenteile, und SPENCER beobachtet bei wiederholter Hin- und Herbiegung abgeschnittener Zweige unter Wasser die Erhöhung der Wasseraufnahme.

Die Untersuchungen von HELLRIEGEL (6), DEHÉRAIN (4) und PAGNOUL (8) über die Beziehungen zwischen der Wasseraufnahme und dem Trockengewicht der Pflanzen in gut resp. schlecht gedüngten Böden zeigen auch die wichtige Rolle, welche die Wasseraufnahme bei dem Ernährungsvorgang spielt.

Obgleich die Abgabe und Aufnahme des Wassers in ihrem Mengenverhältnisse natürlich nicht gleich sind, wie schon VESQUE (16) mit Recht hervorhebt, und auch die abgeschnittenen Zweige in Bezug auf die Wasseraufnahme sich anders verhalten als bewurzelte Pflanzen, so können wir doch durch vorliegende Untersuchungen sicher annehmen, dass bestimmte chemische und physikalische Mittel, sei es als Reizursache oder einfach als mechanischer Faktor, auf die Wasseraufnahme gewissermassen von Bedeutung sein dürften.

Es gab in Japan seit alten Zeiten eine Kunst, „Ikebana“ (Blumenanordnung) genannt, die darin besteht, dass man abgeschnittene Pflanzen, meistens Blumen, in eine mit Wasser gefüllte Vase in schöner Form steckt, sodass die Pflanzen eine Zeit lang in frischem Zustande bleiben können.

Das Vermögen der Wasseraufnahme, welches hier stets als Vorbedingung hinzutritt, ist aber je nach den Pflanzenarten äusserst verschieden; es gibt einerseits natürlich solche, die man ohne besondere Rücksichtnahme wohl monatelang lebend erhalten kann, anderseits aber auch solche, die trotz möglichster Fürsorge sich sogar tagelang nicht frisch halten lassen. Um die Wasseraufnahme in letzterem Fall zu ermöglichen, existierten in der Ikebana-Kunst schon seit einigen Jahrhunderten verschiedene Verfahren, die oft

als Geheimniss hoch geschätzt worden sind.

Diese Verfahren sind natürlich nur durch Erfahrungen gewonnene Erfolge; es liegt uns bisher, meiner Kenntnis nach, irgend eine wissenschaftliche Arbeit in dieser Beziehung nicht vor.

Um diesen Mangel gewissermassen zu erfüllen, wurden die vorliegenden Untersuchungen unter Leitung des Herrn Professor Dr. MIYOSHI im botanischen Institute der Kaiserlichen Universität zu Tokyo ausgeführt. Es sei mir erlaubt, meinem verehrten Lehrer für seine vielseitige Anregung und Unterstützung meinen verbindlichsten Dank auszusprechen.

## II. Liste der Versuchspflanzen.

Als Versuchspflanzen wählte ich folgende Arten, die man gewöhnlich für Ikebana verwendet:

<i>Gleichenia longissima</i> Bl. ....	( <i>Gleicheniaceae</i> .)
<i>Pinus densiflora</i> S. et Z. ....	( <i>Pinaceae</i> .)
<i>Abies firma</i> S. et Z. ....	( „ )
<i>Sciadopitys verticillata</i> S. et Z. ....	( „ )
<i>Podocarpus Nageia</i> R. Br. ....	( <i>Taxaceae</i> )
<i>Podocarpus chinensis</i> Wall. ....	( „ )
<i>Ginkgo biloba</i> L. ....	( <i>Ginkgoaceae</i> .)
<i>Sasa paniculata</i> Makino et Shib. ....	( <i>Gramineae</i> .)
<i>Aspidistra elatior</i> Bl. ....	( <i>Liliaceae</i> .)
<i>Narcissus odoratus</i> L. ....	( <i>Amaryllidaceae</i> .)
<i>Salix purpurea</i> L. ....	( <i>Salicaceae</i> .)
<i>Quercus acuta</i> Thunb. ....	( <i>Fagaceae</i> .)
<i>Ficus Carica</i> L. ....	( <i>Moraceae</i> .)
<i>Morus alba</i> L. ....	( „ )
<i>Ficus erecta</i> Thunb. ....	( „ )
<i>Ficus elastica</i> Roxb. ....	( „ )
<i>Polygonum cuspidatum</i> S. et Z. ....	( <i>Polygonaceae</i> .)

- Achyranthes bidentata* Bl. .... (Amarantaceae.)  
*Nelumbo nucifera* Gertn. .... (Nymphaeaceae.)  
*Nymphaea tetragona* Georg. var. *angusta* Casp ... ( „ )  
*Nuphar japonicum* De. .... ( „ )  
*Anemone japonica* S. et Z. .... (Ranunculaceae.)  
*Laurus nobilis* L. .... (Lauraceae.)  
*Cinnamomum Camphora* Nees. .... ( „ )  
*Macleaya cordata* R. Br. .... (Papaveraceae.)  
*Sedum Telephium* L. .... (Crassulaceae.)  
*Cydonia japonica* Pers. .... (Rosaceae.)  
*Rosa indica* L. .... ( „ )  
*Photinia glabra* Thunb. .... ( „ )  
*Kerria japonica* De. .... ( „ )  
*Pirus sinensis* Lindl. .... ( „ )  
*Lespedeza bicolor* Turcz. .... (Leguminosae.)  
*Pueraria Thunbergiana* Benth. .... ( „ )  
*Euphorbia Sieboldiana* Morr. et Dene. .... (Euphorbiaceae.)  
*Ricinus communis* L. .... ( „ )  
*Daphniphyllum macropodum* Miq. .... ( „ )  
*Ilex otherea* Spreng. .... (Aquifoliaceae.)  
*Acer palmatum* Thunb. .... (Aceraceae.)  
*Impatiens Balsamina* L. .... (Balsaminaceae.)  
*Abutilon striatum* Dicks. .... (Malvaceae.)  
*Sterculia platanifolia* L. .... (Sterculiaceae.)  
*Ternstroemia japonica* Thunb. .... (Theaceae.)  
*Thea japonica* (L.) Nois. .... ( „ )  
*Eurya ochnacea* Szysz. .... ( „ )  
*Eleagnus pungens* Thunb. .... (Elaeagnaceae.)  
*Fatsia japonica* Dene. et Planc. .... (Araliaceae.)  
*Dendropanax japonicum* Seem. .... ( „ )  
*Cornus macrophylla* Wall. .... (Cornaceae.)  
*Aucuba japonica* Thunb. .... ( „ )  
*Rhododendron indicum* Sw. var. *macranthum* Maxim. . (Ericaceae.)



<i>Ardisia japonica</i> Bl.....	(Myrsinaceae.)
<i>Nerium odorum</i> Soland.....	(Apocynaceae.)
<i>Pharbitis hederacea</i> L. ....	(Convolvulaceae.)
<i>Platycodon grandiflorus</i> De.....	(Campanulaceae.)
<i>Sonchus oleraceus</i> L. ....	(Compositae.)
<i>Dahlia variabilis</i> (W.) Desf. ....	( „ )
<i>Ligularia Komppferi</i> S. et Z. ....	( „ )

### III. Dauer der Wasseraufnahme bei abgeschnittenen Zweigen.

Um die Dauer der Wasseraufnahme und den Beginn des Welkens, resp. das Absterben der Ikebanapflanzen zu konstatieren, führte ich mit den oben erwähnten Pflanzenarten eine Reihe Versuche aus, die ich in der folgenden Tabelle zusammenfasse.

Alle Versuchspflanzen schnitt ich unter Wasser ab und steckte sie in besondere Glassgefäße, welche am Nordfenster des Laboratoriums aufgestellt worden waren.

Tabelle I.

Bei den mit \* bezeichneten Pflanzen begann das Welken an der Ansatzstelle des Blattstiels; bei anderen Pflanzen ging das Welken von der Spitze und dem Rande des Blattes aus.

Versuchspflanzen.	Zeit des Schneidens.	Beginn des Welkens.	Zeit des Welkens.	Bemerkungen.
* <i>Pinus densiflora</i> S. et Z.	1 nachm., 7. X, 1910.	21, X, 1910.	18, XI, 1910.	Harz trat aus dem Schnittende aus.
<i>Abies firma</i> S. et Z.	2 nachm., 31. X, 1910.		24, XI, 1910.	Blätter fielen nach 24 Tagen ab.
<i>Ginkgo biloba</i> L.	10 vorm., 9. XI, 1910.		22, XI, 1910.	
<i>Quercus acuta</i> Thunb.	1 nachm., 7. X, 1910.	29, X, 1910.	3, XI, 1910.	
<i>Ficus Carica</i> L. (Zweig.)	11 vorm., 20. X, 1910.	1 nachm., 24. X, 1910.	4 nachm., 24. X, 1910.	Milchsaft trat aus dem Schnittende aus.

Versuchspflanzen.	Zeit des Schneidens.	Peginn des Welkens.	Zeit des Welkens.	Bemerkungen.
<i>Ficus Carica</i> L. (Blatt.)	10 vorm., 24, X, 1910.	10 vorm., 24, X, 1910.	4 nachm., 24, X, 1910.	Milchsaft trat aus dem Schnittende aus.
<i>Morus alba</i> L.	am Mittag, 18, X, 1910.	9 vorm., 19, X, 1910.	23, X, 1910.	
* <i>Ficus elastica</i> Roxb.	1 nachm., 2, XII, 1910.		9, II, 1911.	Gummistoff trat aus dem Schnittende aus.
<i>Ficus erecta</i> Thunb.	10 vorm., 4, V, 1911.	5, V, 1911.	10, V, 1911.	Milchsaft trat aus dem Schnittende aus.
<i>Polygonum cuspidatum</i> S. et Z.	10 vorm., 9, XI, 1910.		13, XI, 1910.	
<i>Nelumbo nucifera</i> Gartn.	am Mittag, 3, X, 1910.		17, X, 1910.	Milchsaft trat aus dem Schnittende aus.
<i>Anemone japonica</i> S. et Z.	am Mittag, 18, X, 1910.	9 vorm., 19, X, 1910.	21, X, 1910.	Blumenblätter fielen nach 1 Tage ab.
<i>Laurus nobilis</i> L.	11 vorm., 15, II, 1911.		1, II, 1911.	
<i>Cinnamomum</i> <i>Camphora</i> Nees.	1 nachm., 2, XII, 1910.		30, II, 1911.	
<i>Macleaya cordata</i> R. Br.	10 vorm., 9, XI, 1910.		13, XI, 1910.	
<i>Keria japonica</i> De.	10 vorm., 8, XI, 1910.	24, XI, 1910.	24, XI, 1910.	
<i>Pirus sinensis</i> Lindl.	1 nachm., 18, IV, 1911.		10, V, 1911.	
<i>Lespedeza bicolor</i> Turcz.	11 vorm., 7, X, 1910.	10, X, 1910.	13, X, 1910.	
"	9 vorm., 27, X, 1910.	9 vorm., 29, X, 1910.	31, XI, 1910.	
<i>Pueraria Thunbergiana</i> Benth.	10 vorm., 7, X, 1910.	12, X, 1910.	17, X, 1910.	
<i>Euphorbia Sieboldiana</i> Morr. et Dene.	am Mittag, 18, X, 1910.	4 nachm., 18, X, 1910.	20, X, 1910.	Milchsaft trat aus dem Schnittende aus.
<i>Ricinus communis</i> L.	am Mittag, 7, X, 1910.	4, XI, 1910.	6, XI, 1910.	
* <i>Daphniphyllum</i> <i>macropodum</i> Mig.	am Mittag, 7, X, 1910.	4, XI, 1910.	25, XI, 1910.	
* <i>Ilex othera</i> Spreng.	1 nachm., 18, IV, 1911.		11, V, 1911.	Blätter fielen nach 23 Tagen ab.
<i>Acer palmatum</i> Thunb.	11 vorm., 7, X, 1910.	24, X, 1910.	29, X, 1910.	

Versuchspflanzen.	Zeit des Schneidens.	Beginn des Welkens.	Zeit des Welkens.	Bemerkungen.
<i>Abutilon striatum</i> Dicks.	2 nachm., 31, X, 1910.		13, XI, 1910.	Blätter fielen nach 13 Tagen ab.
<i>Sterculia platani-</i> <i>folia</i> L.	1 nachm., 7, X, 1910.	10 vorm., 8, X, 1910.	11, X, 1910.	Schleim trat aus dem Schnittende aus
* <i>Ternstroemia</i> <i>japonica</i> Thunb.	am Mittag, 14, XI, 1910.		8, IV, 1911.	
* <i>Thea japonica</i> (L.) Nois.	am Mittag, 7, X, 1910.		23, II, 1911.	Blätter fielen nach 139 Tagen ab.
<i>Elwagnus pungens</i> Thunb.	11 vorm., 15, XI, 1910.		5, XII, 1910.	
* <i>Fatsia japonica</i> Dene. et Planc.	am Mittag, 7, X, 1910.	24, XI, 1910.	15, I, 1911.	Blätter fielen nach 7 Tagen ab; aber der Zweig saugte das Wasser und keimte im nächsten Jahre.
<i>Cornus macrophylla</i> Wall.	10 vorm., 7, X, 1910.	12, X, 1910.	17, X, 1910.	
* <i>Aucuba japonica</i> Thunb.	am Mittag, 7, X, 1910.	26, X, 1910.	17, I, 1911.	
<i>Platycodon grandiflorus</i> Dc.	8 vorm., 19, X, 1910.	5 nachm., 19, X, 1910.	23, X, 1910.	Milchsaft trat aus dem Schnittende aus.
<i>Sonchus oleraceus</i> L.	7 vorm., 27, X, 1910.	5 nachm., 28, X, 1910.	7, XI, 1910.	
<i>Dahlia variabilis</i> (W.) Desf.	10 vorm., 8, XI, 1910.		8, XII, 1910.	
<i>Ligularia Komppferi</i> S. et Z.	am Mittag, 14, XI, 1910.		6, I, 1911.	
<i>Sasa paniculata</i> Makino et Shib.	am Mittag, 7, X, 1910.	10 vorm., 8, X, 1910.	17, X, 1910.	
<i>Narcissus</i> <i>Jonquilla</i> L.	10 vorm., 18, IV, 1911.	23, IV, 1911.	25, IV, 1911.	Schleim trat aus dem Schnittende aus.

Aus der Tabelle ersieht man folgendes:

1. Bei den festen dicken Blättern, zumeist immergrünen Blättern, dauerte die Wasseraufnahme länger als bei den dünnen, zarten Blättern;
2. Bei denjenigen Pflanzen, welche aus dem Schnittende Schleim, Harz und Milchsaft absonderten, kam die Wasseraufnahme schneller zum Stillstand als bei anderen Versuchspflanzen, welche keine derartigen Stoffe enthielten;

3. Bei einigen Pflanzen, welche Wasser schwer aufnehmen, fand das Welken stets am Rande oder an der Spitze des Blattes statt,

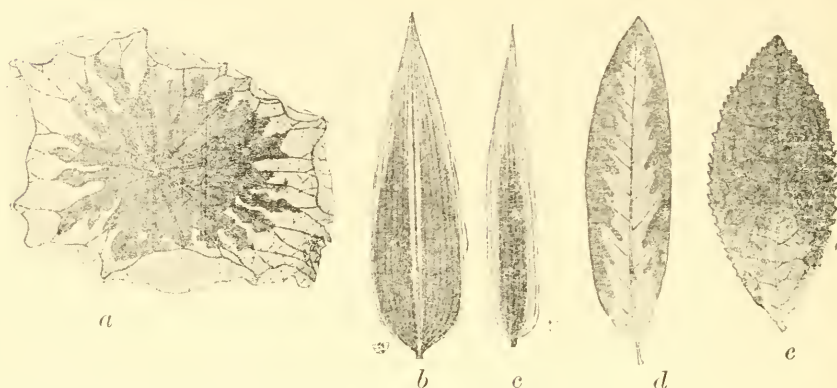


Fig. 1. Art und Weise des Welkens verschiedener Blätter.

a. *Nelumbo mucrifera* Gertn.

b. *Bambusa Veitchii* Carr.

c. *Phyllostachys militis* Riv.

d. *Daphniphyllum macropodum* Miq.

e. *Thea sinensis* L. Gewelkter Teil hell, frischer Teil dunkel gezeichnet.  
(Verkleinert.)

dagegen bei anderen, welche Wasser gut absorbieren, geschah das Welken zuerst dicht neben der Ansatzstelle des Blattstiels ;

4. Bei einigen Pflanzen fielen die Blätter infolge der Bildung der Trennungsschicht bald ab, während die Zweige selbst länger lebend blieben.

#### IV. Grösse der Wasseraufnahme und die Art und Weise des Abschneidens.

Bekanntlich steht die Aufnahmefähigkeit der in der Luft abgeschnittenen Zweige derjenigen der im Wasser abgeschnittenen nach.

Dieses Verhältnis habe ich nach meinen eigenen Versuchen in Tab. II zusammengestellt.



Die Geschwindigkeit des Welkens hängt nach meinen Untersuchungen von der Verminderung der Wasseraufnahmefähigkeit des Zweiges ab. Je geringer die Wasserbewegung im intakten Stengelteile ist, desto langsamer ist auch das Welken der geschnittenen Sprossen.

Wie schon DE VRIES erwiesen hat, ist die Dauer der Berührung der Schnittfläche eines in der Luft durchschnittenen Sprosses mit der Luft von Bedeutung für die Geschwindigkeit des Welkens.

Meine diesbezüglichen Versuche ergaben auch ganz dieselben Resultate. Bei einer Pflanze von *Helianthus annuus* wurde der Spross derart gebogen, dass die Konvexeite des Bogens dicht über die Wasserfläche kam. Sodann wurde der Spross mit einem scharfen, trockenen Messer in der Luft durchgeschnitten, wodurch der abgeschnittene Teil vermöge seiner Elastizität augenblicklich ins Wasser hineinsprang. Die Dauer der Berührung der Schnittfläche mit der Luft war vielleicht nur  $\frac{1}{10}$  Sekunde. Unter den vier so behandelten Sprosstücken, welche je 10 cm lang waren, blieben drei nach 24 Stunden noch frisch, während nur eins derselben nach dieser Zeit zum Teil welke Blätter zeigte.

Erst nach 60 Stunden waren sämtliche Blätter aller vier Stücke verwelkt.

Aus oben beschriebenen Versuchen kann man schliessen, dass sogar eine sehr kurze Dauer der Berührung mit der Luft einen nennenswerten Einfluss auf die Wasseraufnahme ausüben kann.

DE VRIES (5) hat experimentell gezeigt, dass die Leitungsfähigkeit des Zweiges, nachdem er vom Wasser in die Luft gebracht worden ist, nicht in seiner ganzen Länge verändert wird, sondern nur in einer grösseren oder kleineren Strecke oberhalb der Schnittfläche. Schneidet man deshalb bei einem in der Luft abgeschnittenen und demzufolge im Wasser welkenden Sprosse



einen 5–6 cm langen Teil oberhalb des ersten Schnittes unter Wasser ab, so wird letzterer wieder völlig turgescens.

Dass der Effekt eines erneuerten Schnittes unter Wasser für die Wasseraufnahme günstig ist, ist somit klar; aber auch das Wiederschneiden eines derartigen Zweiges in der Luft übt, wie mein diesbezüglicher Versuch bewiesen hat (siehe Tab. III.), einen gewissen vorteiligen Einfluss aus.

Tabelle III.

(A) In der Luft abgeschnittene Zweige.

(B) Derselbe Zweig, dessen Aufnahmefähigkeit sich verminderte.

(C) Derselbe in der Luft wiedergeschnittene Zweig.

Versuchspflanzen.	Alter des Zweiges. Zahl der Blätter.	Blattoberfläche □ cm	Zeit des Abscheidens.	Beginn des Versuchs.	Lufttemperatur °C	Relative Feuchtigkeit %	Aufgenommene Wassermenge pro 1 Stunde cc	Aufgenommene Wassermenge pro □ cm Blattoberfläche pro 1 Stunde cc
<i>Fatsia japonica</i> <i>Dene et Planc.</i>	(A)			1 nachm., 21, III, 1911.	17.8–16.8	33–35	0.78	0.00170
	(B)	1 1	452.353	1 nachm., 21, III, 1911.	16.4–16.5	53–61	0.29	0.00064
	(C)			11 vorm., 30, III, 1911. am Mittag, 30, III, 1911.	16.5	61	0.38	0.00084
<i>Thea japonica</i> (L.) Nois.	(A)			10 vorm., 1, IV, 1911.	16–15	32–30	0.41	0.00112
	(B)	3 17	334.51	10 vorm., 1, IV, 1911.	16.7–19.9	28–25	0.04	0.00011
	(C)			3 nachm., 1, IV, 1911.	17.5	33	0.12	0.00033
<i>Cydonia japonica</i> <i>Pers.</i>	(A)			10 vorm., 13, IV, 1911.	17–17.4	65–66	0.479	0.00171
	(B)	2	280.784	10 vorm., 13, IV, 1911.	17.6	75	0.203	0.00052
	(C)			1 nachm., 17, IV, 1911. 2 nachm., 17, IV, 1911.	17.2	76	0.221	0.00079
<i>Aspidistra elatior</i> Bl.	(A)			am Mittag, 13, IV, 1911.	17.5–17.9	66–67	0.171	0.00055
	(B)	1 1	312.353	am Mittag, 13, IV, 1911.	17.8	75–74	0.041	0.00013
	(C)			2 nachm., 17, IV, 1911.	17.8–17.2	74–76	0.071	0.00023

(A)					1 nachm., 2, V, 1911.	16.3	48	0.184	0.00105	
<i>Polygonum cuspidatum</i> S. et Z.	(B)	1	5	175 058	am Mittag, 2, V, 1911.	10 vorm., 3, V, 1911.	17-19	65-58	0.054	0.00031
	(C)					11 vorm., 3, V, 1911.	17-19	65-58	0.122	0.00070
(A)						2 nachm., 3, V, 1911.	21.8-20.8	59-57	0.078	0.00036
<i>Podocarpus Nagaii</i> R. Br.	(B)	2	18	113.777	2 nachm., 3, V, 1911.	1 nachm., 11, V, 1911.	22.6-22.5	61-60	0.048	0.00022
	(C)					3 nachm., 11, V, 1911.	22.6	61	0.052	0.00024
(A)						11 vorm., 4, V, 1911.	19.2-19.8	66-65	0.192	0.00029
<i>Sasa paniculata</i> Makino et Shib.	(B)	2	4	662.471	10 vorm., 4, V, 1911.	11 vorm., 5, V, 1911.	19.9	76	0.147	0.00022
	(C)					12 vorm., 5, V, 1911.	19.9-20	75-76	0.160	0.00024
(A)						am Mittag, 19, V, 1911.	20.8-21	62	0.357	0.00086
<i>Lysipedeza bicolor</i> Turcz.	(B)	1	35	414.685	10 vorm., 19, V, 1911.	11 vorm., 20, V, 1911.	21.6-22	70-68	0.233	0.00056
	(C)					2 nachm., 20, V, 1911.	22.4-22.6	66.8-65.5	0.269	0.00065

SACHS hat auf Grund seiner Untersuchungen erwiesen, dass die welkenden Sprossen nicht nur durch Hineinpressen des Wassers unter Druck wieder frisch werden, sondern dass dadurch die Leitungsfähigkeit für Wasser wieder auf das normale Mass gebracht werden kann.

In Bezug auf die Tiefe des Eindringens der Luft bei den in der Luft abgeschnittenen Zweigen, hat DE VRIES gezeigt, dass die Luftsäule in den meisten Fällen nicht über 5-6 cm vom Schnittende erreicht. Meine diesbezüglichen Versuche mit *Fatsia japonica* führten zu ganz demselben Resultate.

Was die Art und Weise des Abschneidens anbetrifft, so habe ich gesehen, dass der schiefe Schnitt für die Wasseraufnahme günstiger war, als der rechtwinklige. Dies beruht ohne Zweifel auf der grösseren Fläche für Wasserabsorption. (Siehe Tab. IV.)

Tabelle IV.

(A) Rechtwinkliger Schnitt.

(B) Schiefer Schnitt.

Versuchspflanzen.		Alter des Zweiges, Zahl der Blätter.	Blattoberfläche □ cm	Zeit des Abschneidens.	Beginn des Versuchs.	Lufttemperatur °C	Relative Feuchtigkeit %	Aufgenommene Wassermenge pro 1 Stunde cc	Aufgenommene Wassermenge pro □ cm Blattoberfläche pro 1 Stunde cc
<i>Nelumbo nucifera</i> Gartn.	(A)	1 1	1321.591	12 vorm ,	am Mittag, 29, IX, 1910.	21	69-68	3.38	0.00256
	(B)	1 1	1321.591	29, IX, 1910.	1 nachm., 29, IX, 1910.	21.1	61	4.35	0.00329
<i>Aucuba japonica</i> Thunb.	(A)	2 6	409.79	am Mittag,	1 nachm., 20, V, 1911.	22.1-22.4	67.5-66	0.498	0.00122
	(B)	2 6	409.79	20, V, 1911.	2 nachm., 20, V, 1911.	22.4	66	0.581	0.00142
<i>Daphniphyllum</i> <i>macropodum</i> Miq.	(A)	2 11	317.786	3 nachm.,	3 nachm., 26, V, 1911.	21.7	61	0.294	0.00085
	(B)	2 10	464.163	26, V, 1911.	3 nachm., 26, V, 1911.	21.7	61	0.456	0.00093
<i>Fatsia japonica</i> Dene. et Planc.	(A)	2 1	560.606	am Mittag,	am Mittag, 27, V, 1911.	21.1-21.8	63	0.704	0.00124
	(B)	2 1	573.193	27, V, 1911.	am Mittag, 27, V, 1911.	21.1-21.8	63	0.845	0.00147

## V. Brennen des Schnittendes der Zweige.

Bei der Ikebanakunst wird das Schnittende des Zweiges stets gebrannt, bevor er in die Vase gesteckt wird. Dieses Verfahren beschleunigt die Wasserleitung des Zweiges hauptsächlich dadurch, dass verschiedene organische Stoffe, die oft vom Schnittende austreten und zur Verstopfung der Wasserbahnen führen, insbesondere Milch- und Schleimsaft, sowie Gummistoff, durch Verbrennen verkohlen und beseitigt werden.

Bei den Zweigen der folgenden Pflanzen: *Sterculia platanifolia* (Schleimröhrenbehälter), *Nelumbo nucifera* (Milchröhrenbehälter),

*Euphorbia pulcherrima* (Milchröhrenbehälter), *Ficus Carica* (Milchröhrenbehälter), *Ficus elastica* (Gummigängebehälter) usw. bedarf es des eben gesagten Verfahrens.

Die Zunahme der Leitungsfähigkeit für Wasser beruht auf der Beseitigung der Stoffe, welche die Gefässe der Zweige zum Verstopfen führen. Wenn ein Zweig der *Sterculia platanifolia* im Sommer am Morgen abgeschnitten und sogleich ins Wasser gesteckt wird, so wird er schon nachmittags welken. Man nimmt einen sehr reichlichen Schleimausfluss aus dem Schnittende wahr. Bei *Nelumbo nucifera* ist es auch sehr schwer, ein abgeschnittenes Blatt lebend zu erhalten; das letztere fängt sofort nach dem Schneiden zu welken an. Ähnliches geschieht auch bei *Ficus Carica*.

Es ist ferner bei *Sterculia platanifolia*, *Ficus Carica*, usw. zu beobachten, dass die Blätter der abgeschnittenen und ins Wasser gestellten Zweige langsamer welken, als ein einziges Blatt, welches an der Basis des Blattstiels abgeschnitten und ins Wasser gestellt worden ist. Der Grund liegt darin, dass die Schnittfläche des Blattstiels reichlicheren Milchsaff absondert, als diejenige des Zweiges, und dass infolgedessen die Verstopfung bei dem letzteren schneller eintreten kann.

Bei solchen Fällen führt die Verkohlung des Schnittendes, wie gewöhnlich, zu der Zunahme der Saugkraft des Zweiges. Der auf obige Weise behandelte Spross mit einer Blattoberfläche von *Nelumbo nucifera* von 516.084<sup>mm</sup>, saugte pro Stunde 0.514 cc Wasser, während der nicht gebrannte Spross in gleichem Zustande pro Stunde nur 0.228 cc Wasser saugte.\*

Tab. V zeigt die relative Wasserabsorptionsgrösse der beblättrten Zweige, deren Schnittende abgebrannt resp. nicht abgebrannt wurden.

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\* Über das Aufsteigen des Wasserstroms in verkohlten Pflanzenteilen vergl. STRASBURGER (15).

Tabelle V.

(A) Beblätterte Zweige, deren Schnittende nicht gebrannt wurden  
 (B) Dergleichen mit gebranntem Schnittende.

Versuchspflanzen.		Alter des Zweiges. Zahl der Blätter.	Blattoberfläche □ cm	Zeit des Abscheidens.	Beginn des Versuchs.	Lufttemperatur °C	Relative Feuchtigkeit %	Aufgenommene Wassermenge pro 1 Stunde cc	Aufgenommene Wassermenge pro □ cm Blattoberfläche pro 1 Stunde cc
<i>Nelumbo nucifera</i> Gartn.	(A)	1 1	821.104	11 vorm.,	am Mittag, 26. IX, 1910.	23	80.5-78	0.936	0.00120
	(B)	1 1	889.987	26. IX, 1910.	am Mittag, 26. IX, 1910.	23	80.5-78	2.460	0.00277
<i>Lespedeza bicolor</i> Turcz.	(A)	1 45	205.032	9 vorm.,	1 nachm., 27. X, 1910.	17.7-18	71	0.433	0.00210
	(B)	1 45	202.435	27. X, 1910.	4 nachm., 27. X, 1910.	18.5	69.5	0.567	0.00251
<i>Platycodon</i> <i>grandiflorus</i> DC.	(A)	1 16	166.558	8 vorm.,	9 vorm., 20. X, 1910.	17.5	70	0.097	0.00058
	(B)	1 16	166.558	20. X, 1910.	11 vorm., 20. X, 1910.	17.5	70	0.238	0.00113
<i>Sterculia platani-</i> <i>folia</i> L.	(A)	1 1	633.929	19 vorm.,	10 vorm., 12. X, 1910.	18.5-18.8	87.5-88	0.136	0.00022
	(B)	1 1	633.929	12. X, 1910.	11 vorm., 12. X, 1910.	18.8	88-87	0.714	0.00117
<i>Aucuba japonica</i> Thunb.	(A)	1 6	370.455	11 vorm.,	am Mittag, 17. I, 1911.	5.7-5.9	57-58	0.322	0.00087
	(B)	1 6	520.779	17. I, 1911.	am Mittag, 17. I, 1911.	5.7-5.9	57-58	0.179	0.00092
<i>Euphorbia pul-</i> <i>cherrima</i> Willd.	(A)	1 9	676.461	11 vorm.,	11 vorm., 24. X, 1910.	19.5	74.5	0.456	0.00067
	(B)	1 9	609.416	24. X, 1910.	11 vorm., 24. X, 1910.	19.5	74.5	0.573	0.00094
<i>Ilex otherea</i> Spreng.	(A)	2 18	244.902	9 vorm.,	10 vorm., 17. IV, 1911.	17-17.4	78-77	0.115	0.00047
	(B)	2 18	244.902	17. IV, 1911.	10 vorm., 17. IV, 1911.	17-17.4	78-77	0.176	0.00072
<i>Fatsia japonica</i> Dene. et Planch.	(A)	2 1	599.608	am Mittag.	1 nachm., 25. III, 1911.	16-17.3	45-46	2.390	0.00390
	(B)	2 1	550.392	25. III, 1911.	1 nachm., 25. III, 1911.	16-17.3	45-46	2.410	0.00438
<i>Sasa pinnatifida</i> Makino et Shib.	(A)	1 5	556.818	1 nachm.,	2 nachm., 5. XII, 1910.	10.8	61	0.131	0.00023
	(B)	1 5	556.818	5. XII, 1910.	3 nachm., 5. XII, 1910.	11.8	55.8	0.181	0.00033

## VI. Einfluss verschiedener Stoffe auf die Grösse der Wasseraufnahme durch das Schnittende des Zweiges.

Über den Einfluss von Säuren und Alkali auf die Grösse der Wasseraufnahme haben SENEBIER (14), SACHS (12), BURGERSTEIN (2), PELIGOT (9), SCHRÖDER (13), usw. den Beweis geliefert, dass schwache Säuren die Wasserabsorptionstätigkeit fördern können, während dieselbe durch Alkali vermindert werden kann.

Meine eigenen Versuche mit Weinsteinssäure und Essigsäure einerseits, und mit Natriumbikarbonat andererseits gaben ganz ähnliche Resultate wie diejenigen früherer Forscher.



Fig. 2. Austritt des Schleims aus dem Schnittende des Zweiges (a) und des Blattstiels von *Stereulia plataniifolia*: a. in der Luft, b. im Wasser, s. Schleim.

Allein, es ist zu bemerken, dass bei den Milch-oder Schleim führenden Pflanzen das Verhältnis gerade umgekehrt ist. Z. B. habe ich bei *Nelumbo nucifera*, *Euphorbia pulcherrima*, *Platycodon grandiflorus*, *Stereulia plataniifolia*, usw. konstatiert, dass die Wasseraufnahme in alkalisch reagierendem Wasser vielfach lebhafter ist, als bei gewöhnlichem Wasser. Dies beruht

ohne Zweifel auf dem Umstande, dass das alkalische Wasser Milch und Schleim auflösen kann. Die Resultate der mit obengenannten drei Stoffen ausgeführten Versuche sind in Tab. VI, VII und VIII zusammengestellt.



Tabelle VI.

(A) Kontroll.

(B) In 0.1% Weinsteinsäure.

(C) In 1% Weinsteinsäure.

Versuchspflanzen.		Alter des Zweiges. Zahl der Blätter.	Blattoberfläche □ cm	Zeit des Abschnittens.	Beginn des Versuchs.	Lufttemperatur °C	Relative Feuchtigkeit %	Aufgenommene Wassermenge pro 1 Stunde cc	Aufgenommene Wassermenge pro □ cm Blattoberfläche pro 1 Stunde cc
<i>Nelumbo nucifera</i> Gertn.	(A)	1 1	1202.11	3 nachm., 28, IX, 1910	3 nachm., 29, IX, 1910	21.3-21	63-62	2.358	0.00196
	(B)	1 1	1202.11		4 nachm., 29, IX, 1910	21	62-63	2.635	0.00112
	(C)	1 1	1143.507		4 nachm., 29, IX, 1910	21	62-63	1.482	0.00130
<i>Lespedeza bicolor</i> Turcz.	(A)	1 65	256.331	9 vorm., 27, X, 1910	10 vorm., 27, X, 1910	16	68.5-67	0.404	0.00158
	(B)	1 65	256.331		11 vorm., 27, X, 1910	17	67	0.415	0.00161
	(C)	1 65	256.331		1 nachm., 27, X, 1910	17.4-18	70-71	0.397	0.00155
<i>Sasa paniculata</i> Makino et Shib.	(A)	2 5	1007.955	9 vorm., 7, XII, 1910	10 vorm., 7, XII, 1910	8.9-9	61	0.317	0.00031
	(B)	2 5	1007.955		11 vorm., 7, XII, 1910	9-9.7	61-62	0.361	0.00036
	(C)	2 5	1007.955		am Mittag, 7, XII, 1910	9.7	62	0.193	0.00019
<i>Pinus densiflora</i> S. et Z.	(A)	2	13.180	10 vorm., 26, I, 1911	11 vorm., 26, I, 1911	6.5	65	0.469	0.03558
	(B)	2	12.001		11 vorm., 26, I, 1911	6.5	65	0.454	0.03788
	(C)	2	12.22		11 vorm., 26, I, 1911	6.5	65	0.070	0.00573
<i>Thea japonica</i> Thunb.	(A)	3 10	239.773	2 nachm., 23, I, 1911	2 nachm., 23, I, 1911	9	64-60	0.132	0.00055
	(B)	3 10	248.539		2 nachm., 23, I, 1911	9	64-60	0.143	0.00058
	(C)	3 9	235.714		2 nachm., 23, I, 1911	9	64-60	0.144	0.00061
<i>Aspidistra elatior</i> Bl.	(A)	2 1	239.935	10 vorm., 24, I, 1911	10 vorm., 24, I, 1911	5.3-5.9	60	0.060	0.00025
	(B)	2 1	158.604		10 vorm., 24, I, 1911	5.3-5.9	60	0.046	0.00029
	(C)	2 1	150.487		10 vorm., 24, I, 1911	5.3-5.9	60	0.058	0.00039

<i>Aucuba japonica</i> <i>Thunb.</i>	(A)	2 5	281.169		1 nachm., 24, I, 1911	6.4-6.3	60-59	0.111	0.00040
	(B)	2 6	254.221	1 nachm., 24, I, 1911	1 nachm., 24, I, 1911	6.4-6.3	60-59	0.200	0.00079
	(C)	2 5	186.688		1 nachm., 24, I, 1911	6.4-6.3	60-59	0.186	0.00100
<i>Daphniphyllum</i> <i>macropodum</i> Mig.	(A)	3 13	625.872		11 vorm., 26, I, 1911	8.7-9	65	0.154	0.00024
	(B)	3 18	866.592	10 vorm., 26, I, 1911	11 vorm., 26, I, 1911	8.7-9	65	0.217	0.00025
	(C)	3 14	674.016		11 vorm., 26, I, 1911	8.7-9.1	65-66	0.196	0.00029
<i>Podocarpus</i> <i>chinensis</i> Wall.	(A)	3 42	159.843		3 nachm., 27, I, 1911	9.7-10	65-67	0.054	0.00034
	(B)	3 52	232.284	2 nachm., 27, I, 1911	3 nachm., 27, I, 1911	9.5-10	65-67	0.107	0.00047
	(C)	3 43	186.221		3 nachm., 27, I, 1911	9.5-10	65-67	0.122	0.00066
<i>Sterculia</i> <i>platanifolia</i> L.	(A)	1 1	562.825	am Mittag. 1, XI, 1910	am Mittag. 1, XI, 1910	17.5-18	67-70.5	0.161	0.00029
	(B)	1 1	739.236	10 vorm., 1, XI, 1910	11 vorm., 1, XI, 1910	17-17.3	65-70	0.120	0.00016
	(C)	1 1	739.286	10 vorm., 1, XI, 1910	1 nachm., 1, XI, 1910	17.3	70-72	0.083	0.00011

Tabelle VII.

(A) Kontroll.

(B) In 0.1% Essigsäure.

(C) In 1% Essigsäure.

Versuchspflanzen.		Alter des Zweiges. Zahl der Blätter.		Blattoberfläche □ cm	Zeit des Abschneidens.	Beginn des Versuchs.	Lufttemperatur °C	Relative Feuchtigkeit %	Aufgenommene Wassermenge pro 1 Stunde cc	Aufgenommene Wassermenge pro □ cm Blattoberfläche pro 1 Stunde cc
<i>Bambusa sena-</i> <i>nensis</i> Fr. et Sav.	(A)	2 5	397.835			11 vorm., 14, II, 1911	10.8-11	65	0.132	0.00032
	(B)	2 4	583.465	11 vorm., 14, II, 1911		11 vorm., 14, II, 1911	10.8-11	65	0.814	0.00033
	(C)	2 5	635.236			11 vorm., 14, II, 1911	10.8-11	65	0.219	0.00035
<i>Fatsia japonica</i> <i>Dene. et Planch.</i>	(A)	2 1	429.724			1 nachm., 14, II, 1911	11.3-11.9	65	0.137	0.00030
	(B)	2 1	260.628	am Mittag. 14, II, 1911		1 nachm., 14, II, 1911	11.3-11.9	65	0.078	0.00032
	(C)	2 1	262.795			1 nachm., 14, II, 1911	11.3-11.9	65	0.088	0.00033

<i>Aspidistra elatior</i> Bl.	(A)	2	1	196.654	10 vorm., 16, II, 1911	11 vorm., 16, II, 1911	15-14,9	61-58	0.028	0.00014
	(B)	2	1	206.693		11 vorm., 16, II, 1911	14.6-15	69.5-60	0.044	0.00021
	(C)	2	1	209.055		11 vorm., 16, II, 1911	15-14.9	61-58	0.074	0.00035
<i>Thea japonica</i> (L.) Nois.	(A)	3	9	233.071	am Mittag. 16, II, 1911	2 nachm., 16, II, 1911	14.8-14.6	55-52	0.115	0.00044
	(B)	3	9	261.417		2 nachm., 16, II, 1911	14.8-14.6	55-52	0.114	0.00049
	(C)	3	10	276.181		2 nachm., 16, II, 1911	14.8-14.6	55-52	0.157	0.00056
<i>Aucuba japonica</i> Thunb.	(A)	2	6	342.913	1 nachm., 17, II, 1911	2 nachm., 17, II, 1911	9.4-11	60.5-63	0.222	0.00065
	(B)	2	6	323.032		2 nachm., 17, II, 1911	9.4-11	60.5-63	0.260	0.00080
	(C)	2	5	244.095		2 nachm., 17, II, 1911	9.4-11	60.5-63	0.236	0.00097
<i>Daphniphyllum</i> <i>macropodum</i> Miq.	(A)	12		555.512	11 vorm., 20, II, 1911	11 vorm., 20, II, 1911	6.5-6.9	55	0.160	0.00021
	(B)	12		598.819		11 vorm., 20, II, 1911	6.5-6.9	55	0.144	0.00029
	(C)	13		726.772		11 vorm., 20, II, 1911	6.5-6.9	55	0.236	0.00032
<i>Pinus densiflora</i> S. et Z.	(A)	2		5.427	10 vorm., 21, II, 1911	10 vorm., 21, II, 1911	6.9-7.9	56-58	0.081	0.01493
	(B)	2		3.390		10 vorm., 21, II, 1911	6.9-7.9	56-58	0.130	0.03835
	(C)	2		5.752		10 vorm., 21, II, 1911	6.9-7.9	56-58	0.314	0.05459

Tabelle VIII.

(A) Kontroll.

(B) In 0.1% Natriumbikarbonatlösung.

(C) In 1% Natriumbikarbonatlösung.

Versuchspflanzen.	Alter des Zweiges. Zahl der Blätter.		Blattoberfläche □ <sub>cm</sub>	Zeit des Abschneidens.	Beginn des Versuchs.	Lufttemperatur °	Relative Feuchtigkeit %	Aufgenommene Wassermenge pro 1 Stunde cc	Aufgenommene Wassermenge pro □ <sub>cm</sub> Blattoberfläche pro 1 Stunde cc
<i>Morus alba</i> L.	(A)	1 6	352.11	9 vorm., 26, X, 1910	10 vorm., 26, X, 1910	13.6	79.5-77	1.476	0.00419
	(B)	1 6	352.11		10 vorm., 26, X, 1910	18.6	77-73	1.289	0.00361
	(C)	1 6	352.11		11 vorm., 26, X, 1910	18.6	73-71	0.480	0.00136

<i>Lespedeza bicolor</i> Turcz.	(A)	1 13	197.890	9 vorm., 27, X, 1910	11 vorm., 27, X, 1910	17-17.4	67-70	0.653	0.00330
	(B)	1 12	195.617		am Mittag. 27, X, 1910	17.4	70	0.222	0.00114
	(C)	1 12	195.617		1 nachm., 27, X, 1910	17.4	70	0.181	0.00093
<i>Sterculia platani- folia</i> L.	(A)	1 1	459.740	9 vorm., 25, X, 1910	1 nachm., 25, X, 1910	19	81-83	0.037	0.00008
	(B)	1 1	487.013		1 nachm., 25, X, 1910	19	81-83	0.059	0.00012
	(C)	1 1	487.013		2 nachm., 25, X, 1910	19	84	0.063	0.00013
<i>Euphorbia pulcherrima</i> Willd.	(A)	1 9	676.461	11 vorm., 24, X, 1910	11 vorm., 24, X, 1910	19.5	74.5	0.456	0.00067
	(B)	1 9	676.461		11 vorm., 24, X, 1910	19.5	74.5	0.775	0.00114
	(C)	1 9	676.461		11 vorm., 24, X, 1910	19.5	74.5	0.515	0.00075
<i>Nelumbo nucifera</i> Gaertn.	(A)	1 1	531.656	9 vorm., 5, X, 1910	10 vorm., 5, X, 1910	20.3-21	67.5-67	1.080	0.00203
	(B)	1 1	531.656		11 vorm., 5, X, 1910	21	67-65	1.128	0.00210
	(C)	1 1	531.656		am Mittag. 5, X, 1910	21-21.4	65-63	1.260	0.00237
<i>Platyodon grandiflorus</i> DC.	(A)	1 12	104.058	8 vorm., 20, X, 1910	9 vorm., 20, X, 1910	17.5	70	0.142	0.00135
	(B)	1 12	104.058		11 vorm., 20, X, 1910	17.5	72-68	0.169	0.00153
	(C)	1 12	104.058		am Mittag. 20, X, 1910	18.7	72-68	0.217	0.00209
<i>Sasa paniculata</i> Mukino et Shib.	(A)	1 5	556.818	10 vorm., 5, XII, 1910	11 vorm., 5, XII, 1910	10.1-10.5	62-61	0.418	0.00075
	(B)	1 5	556.818		am Mittag. 5, XII, 1910	10.5-10.8	61	0.245	0.00041
	(C)	1 5	556.818		1 nachm., 5, XII, 1910	10.8-11	61-60	0.121	0.00022
<i>Thea japonica</i> (L.) Nois.	(A)	3 14	363.976	9 vorm., 10, II, 1911	10 vorm., 10, II, 1911	5.8-6.4	60	0.169	0.00046
	(B)	3 10	225.984		10 vorm., 10, II, 1911	5.8-6.4	60	0.074	0.00033
	(C)	3 11	305.315		10 vorm., 10, II, 1911	5.8-6.4	60	0.103	0.00031
<i>Aucuba japonica</i> Thunb.	(A)	2 6	199.213	am Mittag. 10, II, 1911	1 nachm., 10, II, 1911	7.3-7.5	60-61	0.141	0.00071
	(B)	2 6	279.331		1 nachm., 10, II, 1911	7.3-7.5	60-61	0.189	0.00070
	(C)	2 6	253.740		1 nachm., 10, II, 1911	7.3-7.5	60-61	0.178	0.00068
<i>Fatsia japonica</i> Dene. et Planc.	(A)	2 1	302.953	am Mittag. 10, II, 1911	am Mittag. 10, II, 1911	7	59.5-60	0.101	0.00033
	(B)	2 1	434.843		am Mittag. 10, II, 1911	7	59.5-60	0.103	0.00024
	(C)	2 1	434.843		am Mittag. 10, II, 1911	7	59.5-60	0.091	0.00022

<i>Aspidistra elatior</i> Bl.	(A)	2	1	215.172	2 nachm., 10, II, 1911	3 nachm., 10, II, 1911	8	63.5-63	0.066	0.00027
	(B)	2	1	262.992		3 nachm., 10, II, 1911	8	63.5-63	0.071	0.00027
	(B)	2	1	269.291		3 nachm., 10, II, 1911	8	63.5-63	0.071	0.00026
<i>Daphniphyllum</i> <i>macropodium</i> Miq.	(A)	4	16	932.087	9 vorm., 13, II, 1911	10 vorm., 13, II, 1911	7.5-7.7	56-57	0.250	0.00027
	(B)	4	16	674.213		10 vorm., 13, II, 1911	7.5-7.7	56-57	0.170	0.00025
	(C)	4	16	604.721		10 vorm., 13, II, 1911	7.5-7.7	56-57	0.092	0.00015
<i>Podocarpus</i> <i>chinensis</i> Wall.	(A)	3	96	217.126	2 nachm., 13, II, 1911	2 nachm., 13, II, 1911	9.3-10.4	60-64	0.143	0.00080
	(C)	3	78	166.929		2 nachm., 13, II, 1911	9.3-10.4	60-64	0.133	0.00066
	(C)	3	78	224.213		2 nachm., 13, II, 1911	9.3-10.4	60-64	0.142	0.00063

Betreffs der Wirkung der anorganischen und organischen Salze auf die Wasseraufnahme haben SENEBIER (14), SACHS (12), RICÔME (10), WYPLEL (18), PELIGOT (9) u. A. gezeigt, dass die Absorptionstätigkeit der geschnittenen Zweige sich bedeutend beschleunigen oder verlangsamen kann. WOLF (17) findet, dass schon im Brunnenwasser die Transpiration lebhafter als im destillierten ist. Bei meinen Versuchen saugte das Schnittende des Blattstiels von *Nelumbo nucifera* in destilliertem Wasser 0.00183 cc auf 1 □<sup>cm</sup> Blattoberfläche pro 1 Stunde, dagegen im Leitungswasser 0.00228 cc.

Meine eigenen Versuche mit Kaliumnitrat, Natriumchlorid und Alaun, deren Ergebnisse in Tab. IX, X, XI zusammengefasst sind, bestätigten den Befund älterer Forscher vollständig.

Tabelle IX.

- (A) Kontroll.  
 (B) In 0.1% Kaliumnitratlösung.  
 (C) In 1% Kaliumnitratlösung.

Versuchspflanzen.		Alter des Zweiges. Zahl der Blätter.	Blattoberfläche □ cm	Zeit des Abschneidens.	Beginn des Versuchs.	Lufttemperatur °	Relative Feuchtigkeit %	Aufgenommene Wassermenge pro 1 Stunde cc	Aufgenommene Wassermenge pro □ cm Blattoberfläche pro 1 Stunde cc
<i>Daphniphyllum macropodum</i> Miq.	(A)	2 8	314.755	11 vorm., 9, V, 1911	11 vorm., 9, V, 1911	20-20.9	63-59	0.322	0.00093
	(B)	2 8	430.536		11 vorm., 9, V, 1911	20-20.9	63-59	0.313	0.00080
	(C)	2 8	430.536		11 vorm., 9, V, 1911	20-20.9	63-59	0.331	0.00077
<i>Fatsia japonica</i> Dcne. et Planc.	(A)	1 1	480.048	11 vorm., 8, V, 1911	am Mittag. 8, V, 1911	19.7	70-71	0.306	0.00064
	(B)	1 1	440.618		am Mittag. 8, V, 1911	19.7	70-71	0.344	0.00078
	(C)	1 1	418.290		am Mittag. 8, V, 1911	19.7	70-71	0.223	0.00053
<i>Thea japonica</i> (L.) Nois.	(A)	3 18	491.449	10 vorm., 6, V, 1911	11 vorm., 6, V, 1911	16.9-16.7	69-68	0.213	0.00043
	(B)	3 18	482.660		10 vorm., 6, V, 1911	16.9-16.7	69-68	0.383	0.00071
	(C)	3 18	421.378		11 vorm., 6, V, 1911	16.9-16.7	69-68	0.366	0.00087
<i>Aucuba japonica</i> Thunb.	(A)	1 10	401.900	9 vorm., 11, V, 1911	1 nachm., 11, V, 1911	22.6-22.5	61-60	0.192	0.00048
	(B)	1 10	438.955		9 vorm., 11, V, 1911	20.9-21	70-69	0.236	0.00054
	(C)	1 10	487.411		9 vorm., 11, V, 1911	20.9-21	70-69	0.237	0.00049
<i>Aspidistra elatio</i> Bl.	(A)	2 1	258.670	1 nachm., 9, V, 1911	2 nachm., 9, V, 1911	21-21.2	54-61	0.116	0.00045
	(B)	2 1	234.679		2 nachm., 9, V, 1911	21-21.2	54-61	0.101	0.00043
	(C)	2 1	219.240		2 nachm., 9, V, 1911	21-21.2	54-61	0.095	0.00043



Tabelle X.

- (A) Kontroll.  
 (B) In 0.1% Natriumchloridlösung.  
 (C) In 1% Natriumchloridlösung.

Versuchspflanzen.		Alter des Zweiges, Zahl der Blätter.	Blattoberfläche □ cm	Zeit des Abschneidens.	Beginn des Versuchs.	Lufttemperatur °	Relative Feuchtigkeit %	Aufgenommene Wassermenge pro 1 Stunde cc	Aufgenommene Wassermenge pro □ cm Blattoberfläche pro 1 Stunde cc
<i>Lespedeza bicolor Turcz.</i>	(A)	1 57	278.571	9 vorm., 28, X, 1910	11 vorm., 28, X, 1910	17-17.9	77-81	0.366	0.00131
	(B)	1 57	278.571		am Mittag. 28, X, 1910	17.9-18	81-83	0.340	0.00123
	(C)	1 57	278.571		1 nachm., 28, X, 1910	18-18.5	83-82	0.334	0.00120
<i>Bambusa senanensis Fr. et Sav.</i>	(A)	1 4	753.896	9 vorm., 7, XII, 1910	10 vorm., 7, XII, 1910	8.9-9	61	0.310	0.00041
	(B)	1 4	753.896		11 vorm., 7, XII, 1910	9	61	0.250	0.00033
	(C)	1 4	753.896		am Mittag. 7, XII, 1910	9-9.7	61-62	0.227	0.00030

Tabelle XI.

- (A) Kontroll.  
 (B) In 0.1% Alaunlösung.  
 (C) In 1% Alaunlösung.

Versuchspflanzen.		Alter des Zweiges, Zahl der Blätter.	Blattoberfläche □ cm	Zeit des Abschneidens.	Beginn des Versuchs.	Lufttemperatur °	Relative Feuchtigkeit %	Aufgenommene Wassermenge pro 1 Stunde cc	Aufgenommene Wassermenge pro □ cm Blattoberfläche pro 1 Stunde cc
<i>Sasa paniculata Mucino et Shib.</i>	(A)	1 7	893.020	10 vorm., 5, XII, 1910	11 vorm., 5, XII, 1910	10.1	62	0.120	0.00013
	(B)	1 7	893.020		am Mittag. 5, XII, 1910	10.5	61	0.150	0.00017
	(C)	1 7	893.020		1 nachm., 5, XII, 1910	10.8	61	0.153	0.00017

<i>Fatsia japonica</i> <i>Dene. et Planc.</i>	(A)	1	1	346.620	am Mittag. 5, V, 1911	am Mittag. 5, V, 1911	19.7-20	50	0.250	0.00072
	(B)	1	1	258.974		am Mittag. 5, V, 1911	19.7-20	50	0.154	0.00059
	(C)	1	1	303.497		am Mittag. 5, V, 1911	19.7-20	50	0.079	0.00023
<i>Aucuba japonica</i> <i>Thunb.</i>	(A)	1	7	522.844	1 nachm., 5, V, 1911	2 nachm., 5, V, 1911	20.5	46	0.203	0.00039
	(B)	1	7	444.755		2 nachm., 5, V, 1911	20.5	46	0.201	0.00045
	(C)	1	7	493.473		2 nachm., 5, V, 1911	20.5	46	0.219	0.00044
<i>Nuphar japo- nicum</i> DC.	(A)	1	1	102.331	am Mittag. 26, V, 1911	am Mittag. 26, V, 1911	20.9-21.3	60	0.133	0.00120
	(B)	1	1	75.991		am Mittag. 26, V, 1911	20.9-21.3	60	0.094	0.00124
	(C)	1	1	90.676		am Mittag. 26, V, 1911	20.9-21.3	60	0.082	0.00090
<i>Lespedeza bicolor</i> <i>Turcz.</i>	(A)	1	38	541.359	2 nachm., 26, V, 1911	2 nachm., 26, V, 1911	21.6-21.7	60	0.889	0.00162
	(B)	1	36	509.790		2 nachm., 26, V, 1911	21.6-21.7	60	0.663	0.00131
	(C)	1	38	351.748		2 nachm., 26, V, 1911	21.6-21.7	60	0.440	0.00125

Ein anderweitiger Stoff wie Alkohol übt nach meinen Versuchen zuweilen einen günstigen Einfluss auf die Wasseraufnahme aus. Am deutlichsten zeigte sich dies bei *Sasa paniculata*, dessen abgeschnittener Zweig in 10% Alkohol eine viel grössere Wasseraufnahme gegen Kontrollobjekte aufweist. Bei Milchsaff führenden Pflanzen, z. B. *Nelumbo nucifera*, war dagegen keine fördernde Wirkung des Alkohols nachzuweisen. (Siehe Tab. XII.)

Tabelle XII.

(A) Kontroll.

(B) In 0.1% Alkohol.

(C) In 1% Alkohol.

Versuchspflanzen.		Alter des Zweiges.		Blattoberfläche □ cm	Zeit des Abscheidens.	Beginn des Versuchs.	Lufttemperatur °C	Relative Feuchtigkeit %	Aufgenommene Wassermenge pro 1 Stunde cc	Aufgenommene Wassermenge pro □ cm Blattoberfläche pro 1 Stunde cc
		Zahl	der Blätter.							
<i>Nelumbo nucifera</i> Gartn.	(A)	1	1	902.700	2 nachm., 8, X, 1910	2 nachm., 8, X, 1910	21	81.5-81	1.102	0.00132
	(B)	1	1	1149.188		2 nachm., 8, X, 1910	21	81.5-81	1.030	0.00035
	(C)	1	1	1149.188		3 nachm., 8, X, 1910	21	82-82.5	1.056	0.00092
<i>Bambusa</i> <i>senanensis</i> Fr. et Sav.	(A)	1	6	750.649	10 vorm., 27, XI, 1910	10 vorm., 27, XI, 1910	10.8-11	62	0.240	0.00032
	(B)	1	6	750.649		11 vorm., 27, XI, 1910	11.3	60-59.5	0.250	0.00033
	(C)	1	6	750.649		am Mittag. 27, XI, 1910	11.9-12.8	57.5-58	0.312	0.00042

## VII. Zusammenfassung wichtiger Resultate.

1. Die Abnahme der Wasserabsorption aus dem Schnittende eines in der Luft abgeschnittenen Zweiges ist unbedeutend bei denjenigen Pflanzen, die reich an Holzteilen sind, und erheblich gross bei den Milch-, Schleim- oder Gummistoff führenden Gewächsen.

2. Das Brennen des Schnittendes von Zweigen, insbesondere der Milch-, Schleim- oder Gummistoff enthaltenden, ist für die Wasseraufnahme günstig. Infolge der Verkohlung des Schnittendes wird die Verstopfung der Wasserbahnen vermieden.

3. Die Säuren (besonders organische) beschleunigen die Wasserabsorptionstätigkeit, die Alkalien dagegen verlangsamen dieselbe. Bei den Milch-, Schleim- oder Gummistoff führenden Zweigen ist das Verhältnis umgekehrt.

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## Oekologische Studien über Vegetation der Ōta Dünen.

Von

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Mit 2 Tafeln und 8 Textfiguren.

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### I. Einleitung.

In mehreren Ländern existieren Dünen in einer grösseren Ausdehnung, wodurch eine bedeutende Erdoberfläche in unfruchtbarem Zustande verbleibt. Unter denselben sind die Wanderdünen am schlimmsten, weil ihre bewegliche Sandmasse nicht selten den benachbarten Ackerländern und Wohnungen grossen Schaden zufügt. Ziel und Zweck des Dünenbaues liegt daher einerseits in der Nutzbarmachung der Dünen selbst, anderseits in der Beseitigung der zerstörenden Wirkung des Dünenandes. Von diesem Gesichtspunkte aus hat man von früherer Zeit auf die sandbindenden Eigenschaften der auf den Dünen vorkommenden Pflanzen die Aufmerksamkeit gelenkt und versucht, die letzteren gerade im Dünenbau zu verwenden. Das Studium der Dünenpflanzen bildet somit in physiologischer wie biologischer Richtung einen wichtigen und interessanten Teil der Dünenforschung.

In Betreff der Arbeiten über Dünenforschung kommt in erster

Linie GERHALDTS Buch,<sup>1)</sup> welches über eine ausführliche Monographie des Dünenbaues handelt, in Betracht. Besonders stellt der darin enthaltene, von ABROMETT bearbeitete Abschnitt, eine eingehende Schilderung der biologischen und anatomischen Verhältnisse der Dünenpflanzen dar. Dieses Buch kann in seiner Gesamtheit als eine ganz hervorragende Leistung betrachtet werden, doch ist es derzeit, wenigstens seine botanischen Teile, bei den klassischen Untersuchungen einzureihen. Die besten, uns bekannt gewordenen Beobachtungen, die von botanischer Seite über Dünenbildung vorliegen, haben wir WARMING<sup>2)</sup> zu verdanken. Er hat seit 40 Jahren in zahlreichen Abhandlungen die Verbreitung der auf dänischen Dünen vorkommenden Pflanzen und deren oekologische Beziehungen sehr anschaulich geschildert. In der Entwicklungsgeschichte der Dünen gibt REINKE<sup>3)</sup> eine genaue Darstellung der Neubildung von Dünen. Nach seiner Beobachtung entsteht die entwicklungsfähige Anlage einer Düne auf den nassen, salzreichen Sandfeldern durch Zusammenwirken des Sandes und des Windes mit *Triticum junceum*, und sobald diese *Triticum*-Düne hoch geworden ist, so wird das *Triticum* durch die nicht halophytische *Psamma arenaria* abgelöst. Die dichten und höheren Hügel dieser Pflanze fangen mehr Flugsand und halten ihn fester als *Triticum*.

Andere botanische Angaben über Dünen und Dünenpflanzen erbringt eine Anzahl Forscher, namentlich: GILTAY, COWLES, BUCHNEAU, COCKAYNE, MASSART, OLSSON-SEFFER, SOLGER und JESWIET. Unter oben genannten Autoren behandelt COWLES<sup>4)</sup> die geographi-

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sehen Beziehungen der Dünenpflanzen des Michigansees und die ökologischen Faktoren in ihrer Wirkung. Für die Dünenbildung schreibt er vor allem *Ammophila arundinacea* einen wichtigen Einfluss zu. In Werken über die Flora des nordwestlichen Deutschlands gibt BUCHNEAU<sup>1)</sup> die Einwirkung des Windes auf die Pflanzen an. MASSART<sup>2)</sup> schildert vom phytogeographischen Standpunkte das Sandgebilde von Belgien und dessen Vegetation unter Berichtigung der klimatischen Faktoren. OLSSON-SEFFER<sup>3)</sup> bespricht besonders die Wirkung hydromechanischer Faktoren auf das Pflanzenleben sandiger Küsten. Er hat Dünen vieler Länder selbst untersucht und machte vergleichende Darstellungen ihrer Vegetation. LIVINGSTONS<sup>4)</sup> Untersuchungen über Wüstenpflanzen der Arizona erbringen auch wichtige Angaben für die Kenntnis der Dünenpflanzen, insofern es sich um die Einwirkung der Bodentrockenheit auf die Pflanzen handelt. JESWIET<sup>5)</sup> weist klimatische Einflüsse auf holländische Dünen, insbesondere Dünenpflanzen, genauer nach.

Unsere Kenntnis über Dünenkunde wurde besonders durch diesbezügliche Forschung in Deutschland gefördert, wo Dünenuntersuchungen seit mehr als 100 Jahren ausgeführt worden sind. Obwohl viele Probleme über Dünen noch ungelöst bleiben, ist es notwendig, eingehend die Biologie der Dünenpflanzen zu studieren und die verschiedenen äusseren Faktoren, die auf die Dünenvegetation einwirken, genauer zu ermitteln.

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In Japan finden sich Wanderdünen bedeutender Ausdehnung am Meeresstrand vor, besonders in den Provinzen Satzuma, Hitachi, Echigo, Izumo etc. An derartigen Stellen wurde der Dünenbau schon von alters her versucht, ohne aber zum nennenswerten Ergebnisse geführt zu haben.

Für den Dünenbau ist die Dünenforschung absolut unentbehrlich, besonders müssen wir gründliche Untersuchungen über die Lebensweise der Sandbindepflanzen und die möglichste Ausnutzung ihrer biologischen Eigenschaften ausführen. Obwohl wir aus den bisher in fremden Ländern gemachten Untersuchungen über Dünenpflanzen für unseren Fall wichtige Lehren ziehen können, ist doch der Eigentümlichkeit des Klimas und der Flora wegen ein besonderes Studium erforderlich. Mit der Absicht, einen Beitrag zur einheimischen Dünenforschung zu liefern, habe ich vorliegende Arbeit im Laufe des akademischen Jahres 1915–1916 im botanischen Institut zu Tokyo ausgeführt, um vor allem die sandbindende Eigenschaft der Dünenpflanzen, unter Berücksichtigung der Vermehrungsfähigkeit, zu untersuchen.

Meinem hochverehrten Lehrer Herrn Prof. Dr. MIYOSHI, der mich zur vorliegenden Arbeit anregte, sowie für seine vielfache Belehrung und Unterstützung, spreche ich an dieser Stelle meinen verbindlichsten Dank aus. Ebenso bin ich Herrn Prof. Dr. SHIBATA für seine freundlichen Ratschläge und Herrn Assistenten Dr. HIBINO für seine Beihilfe zu grossem Dank verbunden.

## II. Allgemeine Eigenschaften der Dünenpflanzen.

Dünensand besteht grossenteils aus Quarz, doch kommen an den Küstendünen auch Kochsalz und Kalk in gemischtem Zustande vor.

Von den äusseren Einflüssen, die auf die Lebensweise der Dünenpflanzen einwirken, ist die Bodenfeuchtigkeit von grosser Wichtigkeit. Im allgemeinen ist der Wassergehalt des Sandes gering, und der Sand trocknet sehr schnell aus, während dessen obere Schichten von der Sonne stark erwärmt werden. Dadurch wird die Verdunstung aus den darunter liegenden Schichten gehemmt, und es bleibt infolgedessen wenige Dezimeter unter der Oberfläche immer kühl und feucht. Dieses Verhältnis ist zum richtigen Verständnis der Dünenpflanzen von grösster Bedeutung<sup>1)</sup>.

Von den anderen äusseren Faktoren spielen die Wärme, der Wind, das Licht und die Niederschläge eine grosse Rolle.

Die Wichtigkeit des Wärmeeinflusses liegt vorzüglich in der grossen Erwärmungsfähigkeit des Sandes, jedoch übt nicht die hohe Temperatur solch grosse Wirkung auf die Dünenpflanzen aus, sondern insbesondere der bedeutende Temperaturwechsel am Tage und bei Nacht<sup>2)</sup>. Ausserdem hat die Wärme indirekte Bedeutung dadurch, dass das Sättigungsdefizit der Luft und die Transpiration der Pflanzen von ihrer Höhe abhängen.

Die Wirkung des Windes äussert sich in den Dünen, wo er über grosse Flächen ohne Hindernis hinwehen kann. Da die Dünen einen leicht ausgetrockneten Flugsand besitzen, so wirkt der mit Sandkörnern beladene Wind auf die Pflanzen schädigend ein. Der Hauptschaden aber ist der, dass die Blätter infolge allzustarker

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1) Um solche eigentliche Erscheinung im Sande zu erklären, giebt es einige Ansichten; eine von alters her übernommene ist die Theorie der Kapillarität des Sandes. OLSSON-SEFFER (1909. l. c. p. 39) zeigte in seinen genaueren Versuchen, dass die durch Kapillarität erzeugte Wassersteigerung aus dem Grundwasser viel zu gering ist, um diese Erscheinung zu erklären, und führte sie auf die innere Taubildung im Sande zurück.

2) OLSSON-SEFFER zeigt im September einen Lufttemperaturwechsel auf einer Höhe von 25 cm. über dem Boden zwischen Tag und Nacht von 25.6 °C.



Transpiration austrocknen und verdorren. Daher muss darauf Rücksicht genommen werden, dass die Dünenpflanzen gegen den Wind geschützt sind.

Ich will hier auf die anderen Faktoren nicht näher eingehen. Wie jedoch aus der Literatur ersichtlich ist, haben viele Forscher hervorgehoben und deutlich auseinandergesetzt, dass in den Dünen fast alle Bedingungen nur eine allzu gefährliche Verdunstung hervorrufen, und dass demgemäss sämtliche charakteristische Bauorgane der Dünenpflanzen eine Hemmung gegen diesen Übelstand bedeuten. Es unterliegt keinem Zweifel, dass die Meerstrandpflanzen insbesondere gegen Verdunstung spezifische Struktur haben, doch ist es sehr fraglich, ob dies bei allen Dünenpflanzen der Fall ist.

Bei der Dünenforschung zieht man in manchen Fällen nur die Stranddünen in Betracht, und deren Pflanzen werden ohne weiters als echte Dünenpflanzen angesehen. Demgemäss werden die Eigenschaften der auf den Stranddünen wachsenden Xerophyten<sup>1)</sup> oder Halophyten<sup>2)</sup> für die der allgemeinen Dünenpflanzen gehalten. Fast alle Forscher sind sogar dahingekommen, darauf hinzuweisen, dass die Dünenpflanzen nichts anders als Xerophyten sind. Jedenfalls ist es aber nicht zulässig, diese beiden Pflanzentypen in einer gemeinschaftlichen Rubrik unterzubringen.

Es scheint mir, dass die allgemeinen Dünenpflanzen nicht

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1) Hier zeigt der Begriff „Xerophyten“ xerophyte Anpassungen, z. B. wie Jost (Vorles. über Pflanzenphysiologie. 3 Aufl. Jena, 1913 S. 61.) definiert: „Die Pflanzen trockener Standorte, die Einschränkungen in der Transpiration aufweisen, nennt man Xerophyten“; siehe auch WARMING, E.: 1909, p. 235.

2) Halophyten sind natürlich eine Form der Xerophyten, und zwar definierte WARMING (l. c. p. 219): „This arrangement (the very close arrangement between Halophytes und Xerophytes) exists because salt in the soil renders it physiologically dry; a Halophyte, in fact is one form of Xerophyte.“



Querschnittsdicke der Blattgewebe.  
in mm.

Gewebe	vom Meeresstrand	von den Ōta Dünen
Epidermis (Oberfläche)	0.06	0.03
Pallisaden- parenchym	0.24	0.14
Schwamm- parenchym	0.37	0.29
Epidermis (Rückseite)	0.04	0.03
Gesamt	0.71	0.49

immer halophytische oder xerophytische Eigenschaften besitzen<sup>1)</sup>.

Um dies zu erfahren, verglich ich zuerst die Strukturen der Blätter derselben Arten (*Lactuca repens*), die sich sowohl am Strande, wie auf den inneren Dünen, befinden<sup>2)</sup>. Es tritt hierbei in Bezug auf die Blattstruktur sofort zu Tage, dass die Pflanzen der inneren Dünen nicht

bedeutend xerophytische Struktur, wie diejenigen der Stranddünen, besitzen.

Die bisher fast immer bei den Dünenpflanzen charakteristisch nachgewiesenen Strukturen sind meiner Ansicht nach eher auf die Strukturen der Halophyten oder zum mindesten auf diejenigen der Xerophyten zurückzuführen, und daher können wir nicht ein gemeinschaftliches Merkmal bei den Dünenpflanzen in ihren oberirdischen Organen finden. Die Dünenpflanzen, wie ich nachher erwähnen werde, dürfen jedoch auch in die Xerophyten eingereiht werden, wenn wir den Begriff nach KAMERLING annehmen. Er nennt nämlich solche Pflanzen Xerophyten, welche für ihre normale Lebensvorrichtungen verhältnismässig wenig Wasser brauchen, und

1) KEARNEY, T. H. (Are plants of sea beaches and dunes true halophytes? Bot. Gaz. 1904, Vol. XXXVII, p. 433.) veröffentlichte im Jahre 1904 zuerst, dass die Dünenpflanzen nicht immer Halophyten seien, und schloss seine Mitteilungen mit folgenden Worten „all these conditions (strong wind, intense light etc., such causes excessive transpiration) of the environment are common as well to the sandy beaches of great freshwater lakes, so that it is in no way remarkable, from an ecological point of view, that such typical sea coast plants, for example as *Ammophila arenaria*, *Cakili americana*, *Lathyrus maritimus* and *Euphorbia polygonifolia* are likewise found on the shore of Lake Michigan.“

2) Annäherndes Ergebnis wie auch bei *Calystegia Soldanella* wohl bestätigt.

welche infolgedessen sehr widerstandsfähig gegen Transpiration sind<sup>1)</sup>. Wenn wir uns an diese Definition anschliessen sollen, müssen wir jedoch nicht nur die oberirdischen Organe, von denen KAMERLING spricht, sondern auch die unterirdischen in Betracht ziehen. Es soll hierbei nur erwähnt werden, dass die oberirdischen Teile, deren eigentümliche Bauart bisher als wichtiges Merkmal der Dünenpflanzen betrachtet wurde, im wesentlichen für das Kriterium von Dünenpflanzen wenig Wert haben, und dass deren Struktur vielmehr eine spezifische Eigenschaft der Xerophyten oder der Halophyten ist.

Wenn wir in oberirdischen Organen der allgemeinen Dünenpflanzen auch fast keine besonderen Merkmale vorfinden, so müssen wir doch solche in anderen Organen suchen.

Unter den vielen Eigenschaften ist besonders die Widerstandsfähigkeit gegen Sandüberstäubung und Trockenheit der Dünenpflanzen in Bezug auf ihre unterirdischen Organe als ein sehr wichtiges Merkmal der allgemeinen Dünenpflanzen hervorzuheben. Ich möchte darum solche Pflanzen Dünenpflanzen nennen, welche auf dem Sande aufwachsen und der Trockenheit und der Sandüberstäubung widerstehen können.

### III. Geographische Verhältnisse der Ota Dünen.

Wo der Toné Fluss in den Stillen Ozean fliesst, ragt eine Landspitze ins Meer hinein. Zwischen diesem Flusse und der Kashimasee<sup>2)</sup> findet sich ein ausgedehntes sandiges Land vor, auf

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1) KAMERLING, Z.: Welche Pflanzen sollen wir „Xerophyten“ nennen? Flora, 1914, Bd. 106, S. 444.

2) Ein Teil des Stillen Ozeans.

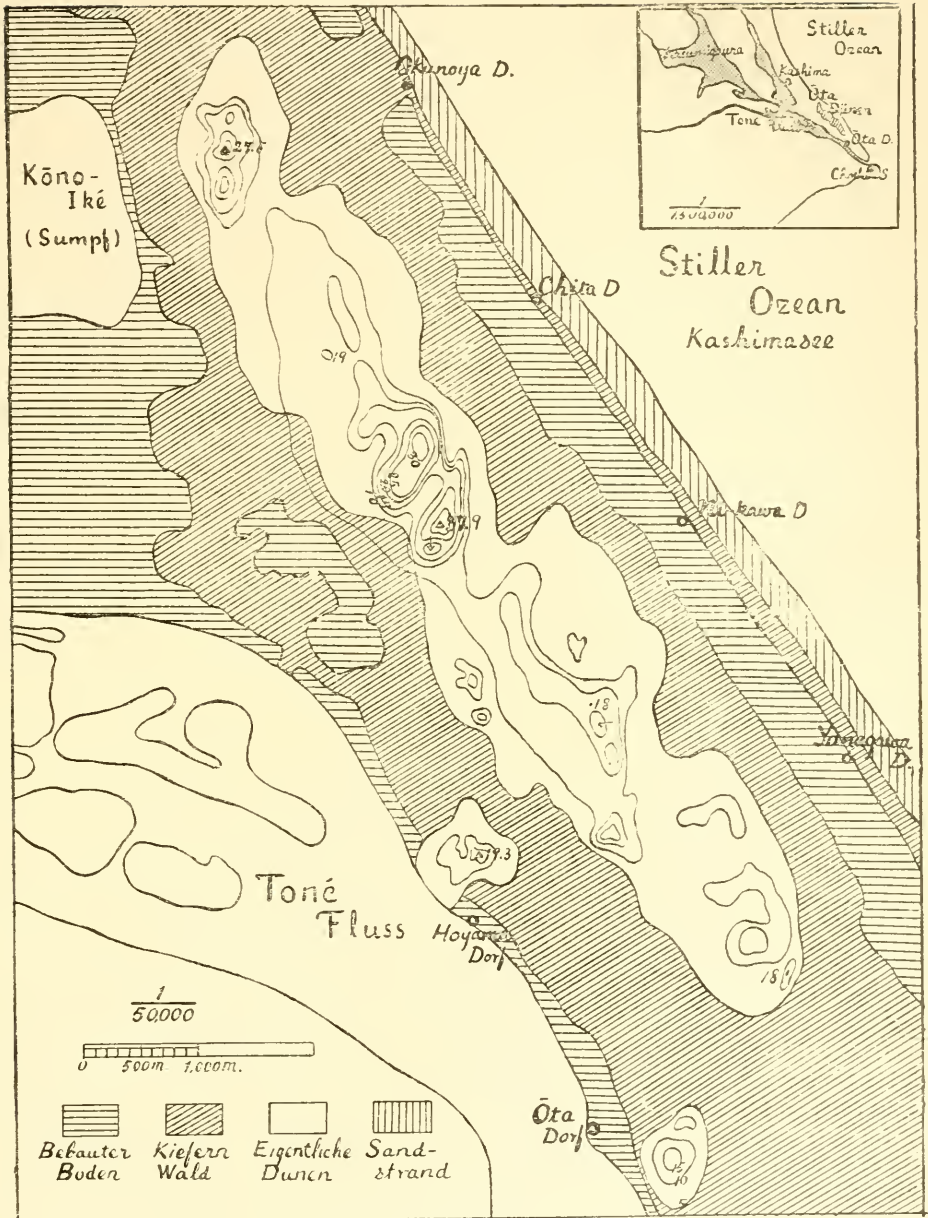


Fig. 1.—Karte der Ōta Dünen nach geographischer Verbreitung der Dünenpflanzen.

Höhenkurven in Metern.

Massstab. 1 : 50,000

welchem die Ōta Dünen<sup>1)</sup> liegen. Es ist wahrscheinlich, dass die Mündung des Toné Flusses früher noch nördlicher lag als jetzt; somit taucht die Vermutung auf, dass das vorliegende Gebiet ein Delta dieses Flusses gewesen sei.

Der Teil der Dünen<sup>2)</sup>, wo ich die vorliegende Untersuchung ausführte, liegt zwischen dem Kōnoiké<sup>3)</sup> Sumpf und Dorf Ōta, und ist durchschnittlich 1.5 km. breit und 10 km. lang. Auf diesem Sandfelde erheben sich hier und da aus beweglichem Sande bestehende Hügelketten, deren Höhen bis zu 40 m. über dem Meeresspiegel reichen. Jede Seite des Landstriches ist vom Flusse resp. Meere durch Kiefernwälder getrennt, nur ein im Westen liegender Teil liegt unmittelbar am Flusse. Nach Osten hin befinden sich längs des Meeres Walldünen. Das Sandgebiet besteht somit aus zweierlei Dünen, nämlich Flussdünen<sup>4)</sup> und Meeresdünen (Fig. 1 und 2). Die Ōta Dünen setzen sich im wesentlichen aus ersteren zusammen.

#### A. Edaphische Bedingungen.

Von den äusseren Bedingungen, die auf Dünenpflanzen einwirken, sehen einige Autoren die edaphischen Bedingungen als entscheidend an, andere legen das Hauptgewicht auf die klimatischen. Da die Sandkörner in der Hauptmasse aus schwer löslichem

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1) Die Ōta Dünen sind die grössten Wanderdünen, die sich in der Nähe von Tokyo befinden; ich bin fünfmal dort gewesen, nämlich im Juni, August und Dezember 1915, und im Mai und August 1916, wo ich Beobachtungen und Versuche über die darauf wachsenden Pflanzen anstellte.

Ich hatte auch Gelegenheit, die Stranddünen bei Ichinomiya, Onjiku, Kugenuma und Kamakura zu betrachten, und aus letzteren Dünen wurde das Material für die Laboratriumversuche hauptsächlich gesammelt.

2) In der Geologie wird oft der Begriff „Dünen“ auf sichtbare, sandige Hügel beschränkt, ich verstehe hier jedoch unter Dünen das ganze sandige Feld.

3) Ein einziger grosser Sumpf im vorliegenden Sandfelde, dessen Umfang über 6 km. beträgt.

4) Der Begriff „Flussdünen“ und „Meeresdünen“ ist ein genetischer; bei Vornahme einer orthographischen Trennung ist es deshalb besser, von Binnendünen gegenüber äusseren Dünen zu sprechen.

Quarz bestehen, kann man sich nicht vorstellen, dass bei den Dünen die edaphischen Bedingungen eine so wichtige Rolle spielen sollen, wie die klimatischen.

### 1. Kalkgehalt.

Dass die Verbreitung der Dünenpflanzen vom Kalkgehalt des Bodens abhängig ist, hat JESWIET<sup>1)</sup> berichtet. Dies ist aber bei den Ōta Dünen nicht der Fall, da der dortige Sandboden arm an Kalk ist.

### 2. Kochsalzgehalt.

Der Kochsalzgehalt des Sandbodens in den besprochenen Dünen ist gering. Die Analyse von Grundwasser<sup>2)</sup> zeigt einen Kochsalzgehalt von 4.96 mg. pro. L. Man kann nicht annehmen, dass ein derartig geringer Kochsalzgehalt im Grundwasser eine nennenswerte Wirkung auf die Dünenpflanzen ausüben kann.

### 3. Korngrösse.

Die Erkenntnis der Korngrösse ist von grosser Wichtigkeit, da die Korngrösse des Dünenandes unmittelbar zu der Zerstreuung des Sandes in Beziehung steht, und die Sandkörner wegen ihres verschiedenen Wassergehaltes unmittelbar auf die Ver-

TABELLE I.  
Korngrösse des Dünenandes.

Herkunft des Sandes	Tiefe in cm.	Korngrösse in mm. auf %			
		<0.1	0.1—0.3	0.3—0.5	0.5<
Muster A von dem Abhang einer niedrigen Erhöhung im Sandfelde	Oberfl.	4	62	24	10
	20	4	42	25	29
	50	6	51	22	21
	100	7	62	20	11
Muster B von dem Gipfel eines Hügels etwa 20 m. Höhe	Oberfl.	9	62	19	10
	20	8	62	20	10
	50	5	64	23	8

1) JESWIET, J.: 1913. I. c S. 271.

2) Das Wasser wurde aus einem Brunnen geschöpft, der in der Mitte des Dünenfeldes, 1 km. von dem Tone Fluss und 3 km. von der Kashimasee entfernt ist.



breitung der Dünenpflanzen einwirken können. Auf vorhergehender Tabelle I gebe ich die Grösse der an zwei Stellen entnommenen Sandkörner.

Wie aus dieser Tabelle ersichtlich ist, schwankt der grösste Teil der Sandkörner zwischen 0.3 und 0.1 mm. Durchmesser.

Das Muster A zeigt, dass sich auf der Oberfläche grösstenteils feinere Körner vorfinden. In der Tiefe von 20 cm. nehmen die gröberen Körner zu, aber dann nehmen sie wieder je nach der Tiefe ab, während die feineren zunehmen. Aus dem Muster B erkennen wir, dass der Höhenrand der Dünenkette ganz aus feinen Körnern besteht. Hieraus ersieht man, dass die feineren Sandkörner, von der ausgetrockneten Schicht her, gegen den Höhenrand geweht werden, während die gröberen nach und nach an den niederen Stellen zurückbleiben.

Die Farbe des Sandes in den Ōta Dünen ist bräunlichrot wegen des reichlichen Eisengehalts.

## B. Klimatische Bedingungen.

Das klimatische Verhältnis der Ōta Dünen ist mit der nahe liegenden Stadt Chōshi annähernd gleich. Folgende Tabelle ist ein Auszug aus den meteorologischen Beobachtungen der Station Chōshi<sup>1)</sup>.

### TABELLE II.

Resultate der meteorologischen Beobachtungen für das  
Lustrum 1906–1910 für Chōshi.

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1) Die meteorologische Station Chōshi liegt an der Mündung des Tone Flusses, auf Lat. N 35°44', Long. E. 140°10', im Südosten ca. 12 km. von den Ōta Dünen entfernt. Siehe Fig. 1. S. 9.



Monat	Atm. Temp. °C			Feuchtigkeit (Durchschnittl.) Mittlere	Regen in mm.	Zahl der Tage					Wind m/s	
	Monat Mittlere	Max.	Min.			Klar	Trüb	Sonnen- los	Sturm Wind	Frost	Mittlere Geschw. f. 2fh.	Richtung d. vorherrsch. Windes
Jan.	5.6	9.3	1.8	70	117.7	7	10	7	15	13	6.8	S
Feb.	4.5	8.2	0.8	63	85.1	7	8	4	13	12	6.2	WNW
März	7.4	10.8	4.0	72	171.8	4	15	7	19	7	7.2	SE
April	12.7	15.8	9.4	78	125.6	4	13	6	15	1	7.2	SSW
Mai	16.2	19.1	13.3	82	119.4	3	14	5	14	0	6.7	SE
Juni	19.0	21.6	16.7	88	174.1	1	18	7	11	0	5.9	SW
Juli	22.1	24.7	20.1	90	151.0	2	16	6	10	0	6.1	SSW
Aug.	24.5	27.0	22.4	88	172.6	3	10	2	10	0	6.4	SSE
Sept.	21.4	23.6	19.3	84	225.9	1	16	9	15	0	7.2	NNE
Oct.	17.3	19.9	14.5	78	230.4	3	14	8	17	0	6.7	NNE
Nov.	12.5	15.9	8.8	72	110.0	6	9	6	14	3	6.0	SSE
Dez.	7.1	11.4	2.7	66	53.8	10	4	2	11	14	5.1	SSW
Jahres	14.3	17.3	11.2	77	1737.4	51	147	69	164	50	6.4	S

Da die Öta Dünen zwischen Meer und Fluss liegen, herrscht ein Küstenklima vor, das sich durch verhältnismässig kühlen Sommer, milden Winter und grosse Luftfeuchtigkeit kennzeichnet.

Die Niederschläge sind besonders im Herbste gross und der Winter ist in der Regel trocken. Während aller Jahreszeiten wehen vorherrschend Südwinde, welche im dürrenden Winter die Trockenheit erhöhen und den Sand als Staubwolken weit befördern. Es giebt öfters Frost im Winter, aber selten Schnee.

Das Wachsen der Dünenpflanzen kann erst gegen Ende März vor sich gehen, wenn die mittlere Tageswärme schon auf ungefähr 10°C zu steigen vermag. Schon Anfang April bedecken sich die *Carex*-Arten mit Blüten, aber die anderen Gräser und Kräuter blühen erst im Frühsommer, und gegen Ende Juni erreicht die

Blüte ihren Höhepunkt. Nach der Regenzeit<sup>1)</sup> im Frühsommer kann die Hitze in den Dünen bereits ziemlich stark werden, aber selbst im Hochsommer können viele Dünenpflanzen die Hitze gut ertragen. Diese Periode dauert zwei Monate, während welcher die Früchte mancher Dünenpflanzen schon reif werden und ihre Entwicklungsfähigkeit allmählich abnimmt. Hierauf folgen im September und October gewöhnlich Regenfälle, wobei sich niedrig liegende Landflächen mit Regenwasser anfüllen. Schliesslich tritt eine kalte Dürreperiode ein. Dadurch gehen alle oberirdischen Teile der Dünenpflanzen zu Grunde, und der Flugsand fängt sich zu bewegen an.

Da sämtliche klimatischen Verhältnisse immer grossen Einfluss auf die Eigentümlichkeit der Dünenvegetation ausüben, werden dieselben nachstehend einzeln und abgesondert kurz behandelt:

#### 1. Wind.

In diesem ungeschützten Sandfelde wehen häufige und heftige Winde das ganze Jahr hindurch, aber wie man aus der Tab. II ersieht, herrschen hauptsächlich Südwinde vor, welche nicht nur am häufigsten, sondern im Winter zugleich auch am heftigsten wehen. Die Wirkung solcher Winde äussert sich dort in den einseitig wachsenden gedrehten Zweigen von vielen Sträuchern, besonders von *Juniperus rigida*. Gemäss der vorherrschenden Winde laufen viele langen Reihen gürtelartiger Dünenketten von Nordwest nach Südost. Deshalb befindet sich die Windseite der Dünen nach dem Toné Fluss zu. Diese Ausdehnung der Dünenkette ist für die Dünentopographie und demgemäss für die Verbreitung der Dünenpflanzen von grosser Wichtigkeit. Bekannterweise werden selbst von mittelstarkem Winde grosse Sandmengen in die Höhe

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1) Die Regenzeit beginnt in Japan Anfang Juni und dauert ungefähr einen Monat lang.

gehoben und weiter befördert. Nach SOKOLOWS<sup>1)</sup> Versuchen über das Verhältnis der Windstärke und Korngrösse, ist erstere in den Ōta Dünen vollkommen genug, ungefähr 70% der Sandkörner von einem Dünengipfel abzuwehen, wie aus Tab. I (S. 11) and II (S. 13) hervorgeht.

## 2. Regen und Bodenfeuchtigkeit.

Der monatliche Durchschnitt der Regenmenge in Chōshi für den Zeitraum von 10 Jahren ist wie folgt:

TABELLE III<sup>2)</sup>.

Regenmenge für das Lustrum 1901–1910 für Chōshi.

Jahre	Jan.	Feb.	Mar.	Apr.	Mai	Jun.	Juli	Aug.	Sep.	Oct.	Nov.	Dez.	Gesamt
1901	93	71	119	162	125	157	231	55	115	324	69	67	1579
1902	48	43	147	96	248	112	192	258	171	127	146	211	1832
1903	214	136	195	201	133	107	243	27	157	421	208	67	2117
1904	22	107	208	142	133	49	50	212	169	305	48	101	1516
1905	95	64	133	234	125	215	85	222	88	157	94	129	1641
1906	57	211	107	59	48	107	345	63	282	196	140	27	1725
1907	130	11	112	147	115	183	75	139	132	200	222	46	1508
1908	60	59	278	188	171	235	159	248	159	100	39	133	1920
1909	184	68	268	143	152	187	76	61	277	376	65	16	1597
1910	158	76	94	91	110	159	101	352	279	249	94	48	1938
Mittel	106	85	166	146	136	154	156	164	183	193	110	85	1740

Die grösste Menge des Regens fällt in den Monaten September

1) SOKOLOWS gibt folgende Tabelle für das Verhältnis zwischen Windstärke und Grösse der weggewehten Sandkörner:

Windstärke m/s	Korngrösse in mm.
4.5— 6.7	0.25
6.7— 8.4	0.50
9.8 — 11.4	1.00

(Zt. JESWIET, 1913, l. c. S. 332.)

2) Die Tabellen II und III entnahm ich aus den Jahresberichten der Zentrale des Meteorologischen Observatoriums zu Tokyo.

und October. Zu dieser Zeit sind die auf dem niedrigen Dünenfelde wachsenden Pflanzen, z. B. *Carex pumila*, ganz unter Wasser. Dagegen sind die Niederschläge von November bis Februar weniger, und die Bodenfeuchtigkeit ist daher in dieser Jahreszeit nicht ausreichend. Das ist eine Ursache, warum die Ōta Dünen im Winter beweglich werden. Ferner können wir aus obiger Tab. III sehen, dass die plötzliche Zunahme des Regens im März, zusammen mit der aufsteigenden Wärme, die Keimung oder Entfaltung der Dünenpflanzen fördert.

Betreffs der Bodenfeuchtigkeit ist es zuerst eine wichtige Frage, wie tief das Grundwasserniveau in den Dünen liegt. Nach gelegentlichen Beobachtungen, die ich bei einem Brunnen<sup>1)</sup> gemacht habe, war die jährliche Schwankung des Wasserniveaus zwischen 2–4 m. Tiefe. Obwohl die Wassersteigung durch Kapillarität gering ist<sup>2)</sup>, scheint es mir, dass ein derartig seichtes Grundwasserniveau als Wasserspeicher für die darauf liegende Sandmasse dienen kann.

Der Wassergehalt des Sandbodens in der trockenen Zeit<sup>3)</sup>, wie ich untersuchte, war folgendes:

Tiefe in cm.	Wassergehalt in %
Oberfl.	1.0
20	5.7
50	5.8
100	6.3

Aus dieser Tabelle sieht man, dass die Oberfläche des Bodens leicht ausgetrocknet ist, die darunter liegenden Schichten jedoch

1) Betreffs dieses Brunnens erklärte ich in der Fussnote auf S. 11.

2) WARMING (1909, l. c. p. 59. eff. auch S. 5 in vorliegender Arbeit) zeigte, dass das Vermögen des Sandes, aus dem Untergrunde Wasser aufzusaugen, in der Regel sehr gering ist, das Wasser in der Regel höchstens  $\frac{1}{2}$  m. gehoben wird.

3) Am 23 Dez. 1915, nach einigen andauernd schönen Tagen. Am Abhange eines kleinen Hügels.

schon in der Tiefe von 20 cm., selbst in der trockenen Zeit, noch immer nass sind.

### 3. Wärme und Bodentemperatur.

Wie aus Tab. II. klar ersichtlich ist, sinkt die Temperatur im Februar am meisten, doch fällt die mittlere Temperatur nicht unter  $4.5^{\circ}\text{C}$ .

Da für das Pflanzenleben in den Dünen die Erwärmung des Bodens eine grosse Rolle spielt, machte ich diesbezügliche Beobachtungen, die ich hier folgen lasse: Am 14. August 1915, 10 Uhr vorm., war die Temperatur der Sandoberfläche  $63^{\circ}\text{C}$ , während die Lufttemperatur  $\frac{1}{3}$  m. über dem Boden  $42^{\circ}\text{C}$  zeigte. Am 23. Dezember, 10 Uhr vorm., war die Bodentemperatur in verschiedenen Tiefen, bei einer Temperatur der Bodenoberfläche von  $10^{\circ}\text{C}$ , wie folgt:

20 cm. Tiefe	$9.5^{\circ}\text{C}$ .
50 „ „	$10.5^{\circ}\text{C}$ .
100 „ „	$12^{\circ}\text{C}$ .

Die durch Sonnenschein hervorgerufenen Temperaturveränderungen zeigten am 28. April 1916 folgende Schwankungen:

Nachmittags	Bodenoberfläche	In der Tiefe von 10 cm.
2 Uhr	$41^{\circ}\text{C}$ .	$26^{\circ}\text{C}$ .
4 „	$31^{\circ}\text{C}$ .	$26^{\circ}\text{C}$ .
5 „	$30.5^{\circ}\text{C}$ .	$25.5^{\circ}\text{C}$ .

Dieser Versuch zeigt, wie stark in den Dünen die Temperatur der Bodenoberfläche von der Sonnenbeleuchtung abhängig ist.

## IV. Verbreitung der Dünenpflanzen auf den Ōta Dünen.

WARMING<sup>1)</sup> teilt die Dünen von Jütland in drei Vereinsklassen

1) WARMING, E.: 1909, l. c. p. 263-268. Vgl. auch SCHWELLENGREBEL, N.: Über niederländische Dünenpflanzen. Beih. z. bot. Cent. 1905, Bd. XVIII, S. 184.

ein: Sandstrand, worauf psammophile Halophyten vegetieren; weisse Dünen, worauf nur solche Pflanzen zu wachsen vermögen, welche eine Sandüberstäubung vertragen können und graue Dünen, worauf auch weniger widerstandsfähige Pflanzen gedeihen können. Wir können auch bei den Ōta Dünen (Fig. 1 und 2) ungefähr diese drei Arten wiederfinden. Die Walddünen längs der Kashimasee kommen den ersteren gleich, doch der grösste Teil der

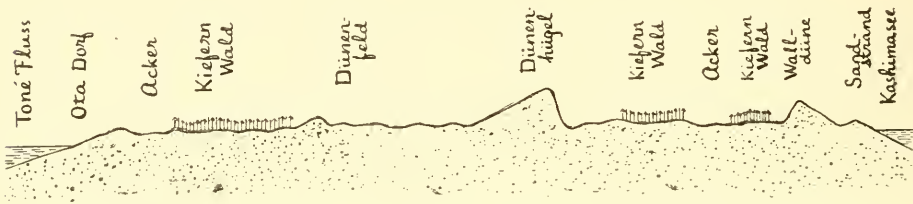


Fig. 2.—Querprofil der Ōta Dünen (etwas schematisch) Vgl. Fig. 1.

Ōta Dünen gehört zu den grauen Dünen, die eher als Dünenfeld oder Sandfeld anzusehen sind, und auf welchen bewegliche weisse Dünen hier und da zerstreut liegen. Dazu möchte ich noch eine vierte Klasse, nämlich Walddünen, hinzusetzen.

#### A. Geographische Verbreitung der Dünenflora.

##### 1. Vegetation des Sandstrandes.

Längs dem Stillen Ozean laufen liniare Stranddünen, die durchschnittlich 300 oder 400 m. von der Küste entfernt sind. Zwischen den Dünen und dem Strand treten stellenweise niedrige Vordünen hervor (Taf. I, Fig. 4).

Auf der Sandfläche, welche von den Meereswellen bespült wird, mangelt es an Vegetation. Weiter zurück gelegen, sieht man zuerst psammophile Halophyten, dann folgen Psammophyten auf



dem von Wogen nicht mehr gespülten Sandstrand. Dort ist der Boden noch etwas salzhaltig, und es herrschen überaus heftige Winde vor; daher finden wir halophytische oder xerophytische Pflanzen, die mit Einrichtungen versehen sind, welche zur Hemmung grosser Verdunstung dienen. *Wedelia prostrata* kommt auf den seewärts abfallenden Abhängen der Vordünen vor, wo sich Sanderhöhen bilden. Diese Pflanze kriecht am Sandboden durch die mächtig entwickelten oberirdischen Ausläufer vorwärts. Sie ist eine in diesem Gebiete typische psammophile Halophyte. Merkwürdig ist es, dass sie sich nicht nach dem inneren Sandfelde verbreitet, obwohl sie in kultiviertem Zustande auch auf koehsalzfreiem Sandboden wohl gedeihen kann. Ferner kommen mehrjährige Kräuter mit kriechenden Rhizomen vor: *Carex macrocephala*, *C. pumila*, *Phellopterus littoralis* und *Lactuca repens*. Diese Kräuter, wie unten erwähnt, sind die Hauptpflanzen, die man stets in den betreffenden Dünen trifft. Die Formationen von *Vitex trifolia* var. *obata* und von *Tournefortia sibirica* sind in dieser Zone beschränkt. *Elymus arenarius*, *Atriplex tatarica*, stellenweise *Lippia nodiflora* und *Arabis Stelleri* var. *japonica* wachsen in diesem Gebiete. An den vom Meer entfernten, etwas befestigten Stellen finden wir *Lathylus maritimus*, *Calystegia Soldanella*, *Artemisia annua*, *Oenothera odorata*, *Viola Patrinii* var. *chinensis*, *Lotus corniculatus* etc., und besonders haben *Imperata arundinacea* den Boden fast ganz bedeckt.

## 2. Vegetation der Walddünen.

Diese Klasse findet sich an den beiden Rändern des Sandfeldes vor. Die grösseren Teile sind schon mit Kiefern (*Pinus Thunbergii*) bepflanzt und haben sich in schönen Wald verwandelt (Taf. I, Fig. 1). Viele Binnenlandpflanzen haben sich hier angesiedelt. Am häufigsten kommt unter diesen Walddünen *Imperata arundi-*

*nacca* vor, deren unterirdische Rhizome anderen Waldpflanzen durch Befestigung des Sandbodens als Gerüst dienen. Im Zusammenhang mit obigem Gras bemerken wir Moose. Es sind zweierlei Moose: *Racomitrium canescens* und *Polystrichum commune*. Während das erstere auf ausgetrockneten, beleuchteten Stellen wuchert, wächst das letztere auf den durch Kiefern beschatteten Plätzen. Diese Moose, besonders das erstere, sind für die Befestigung des Sandbodens von Wichtigkeit. Ein bedeutendes Gewächs in diesen Walddünen ist *Rosa Luciae*, die durch ihre mächtig entwickelten, kriechenden Stämme öfters den 20 m. breiten Boden bedeckt. *Oenothera odorata* gedeiht auch hier gut und andere im Sandfelde vorkommenden Pflanzen, wie z. B. *Juniperus rigida*, *Eleagnus fragrans*, *Calystegia Soldanella*, *Artemisia annua* etc. gesellen sich zu den oben beschriebenen Pflanzen. Als Vertreter vieler Ansiedler der Binnenlandspflanzen heben wir besonders *Panicum sanguinale* und *Erigeron linifolius* hervor.

### 3. Vegetation der weissen Dünen.

Da die eigentlichen Ōta Dünen als weisse Dünen und Dünenfeld bestehen, so wollen wir sie hier näher betrachten.

## B. Topographische Verbreitung der Dünenflora.

Nach ihrer topographischen Verbreitung können wir die Dünenpflanzen auf weissen Dünen und Dünenfeld in drei Kategorien einteilen:

1. Pflanzen, die hauptsächlich am Gipfel des Sandhügels vorkommen. 2. Pflanzen, die auf niederem Felde wachsen. 3. Pflanzen, die auf dem übrigen flachen Felde vegetieren. Ich möchte hier nach diesen drei verschiedenen Kategorien sowohl die klimatischen Verhältnisse, wie die Flora jedes Vereins, beschreiben.

### 1. Der Gipfel des Sandhügels.

Wie ich schon erwähnte, laufen zerstreut von Süden nach Norden viele weisse Dünenketten in ausgedehntem Sandfelde. Der Gipfel dieser Dünen besteht aus Flugsand, der wegen der starken Isolation leicht ausgetrocknet und durch heftige Winde weggeblasen wird; daher ist die Vegetation der weissen Dünen sehr karg und arm. Stellenweise sind diese Sandhügel ohne jedwede Vegetation und bleiben kahl. Auf den Gipfeln gedeihen nur derartige Pflanzen, die starke Verdunstung und Sandüberstäubung ertragen und überdies durch Rhizome an jeder begünstigten Stelle spriessen können. *Carex macrocephala* ist die einzige Pflanze, die solche ungünstigen Bedingungen erfüllt. Sie ist daher als erster Ansiedler beweglicher Dünen anzusehen. Durch ihre verbreiteten Erdstengel stellt sie die bedeutendste Formation auf fast jedem Gipfel der Dünen dar (Taf. II, Fig. 8). Diese Formation wird allmählich durch *Phellopterus littoralis* verdrängt und auf verschiedene Stellen zerstreut. Die Windseite der Dünen entbehrt in der Regel jedweder Vegetation, aber die Leeseite ist mit *Carex macrocephala* und *Phellopterus littoralis* bewachsen und öfters findet sich sogar andere Vegetation vor.

## 2. Das niedere Feld.

Das zu der zweiten Kategorie gehörende, tiefer gelegene und feuchte Dünenfeld findet sich nicht nur zwischen den Kuppen jeder Düne als Sandmulde, sondern solche niederen Stellen kommen auch auf dem ausgedehnten Dünenfelde zerstreut vor; bei grossen Niederschlägen verwandeln sie sich in einen Teich oder in einen Fluss (Taf. I, Fig. 3); dabei bildet sich eine Humusschicht auf dem Sande, welche eine grosse Rolle als Nährboden spielt. Derartiger Boden erhält sich selbst im heissen Sommer längere Zeit feucht. Die an solchen Stellen wachsenden Pflanzen müssen daher sowohl eine trockene wie eine nasse Zeit ertragen können. *Carex pumila*

ist als typisches Gewächs hierfür anzusehen. Es vermehrt sich durch Rhizome und bildet eine verbreitete Formation (Taf. II, Fig. 7). *Ischaemum muticum*, *Phellopterus littoralis*, öfters *Calystegia Soldanella* und *Lactuca repens* können auch an diesen niederen Stellen gedeihen.

Wir haben auch hier stellenweise sog. Dünenkessel, deren Boden immer ganz durchnässt ist, und wo daher solche hydrophilen Pflanzen, wie *Utricularia affinis*, *Lycopus lucidus* var. *hirtus*, *Mitrasacme alsinoides*, *Pemphis acidula* etc. gut fortkommen.

### 3. Das flache Sandfeld.

Die Ōta Dünen stellen zum grössten Teil ausgedehnte Sandflächen dar. Deshalb finden sich hier die meisten Dünenpflanzen. *Ischaemum anthephoroides* und *Phellopterus littoralis* sind hier von grosser Bedeutung. Während die erstere Pflanze in Halmbüscheln dicht wächst, steht die letztere vereinzelt. Die Sandkörner fangen sich hinter den *Ischaemum*-pflanzen, deren jede einen kleinen Sandhügel bildet. Ich sah dieselben jedoch niemals grösser werden, um sie als Dünenanlage betrachten zu können<sup>1)</sup>, doch dient dieses Gras als wichtige sandverbindende Pflanze. *Ischaemum anthephoroides* und *I. muticum* finden sich öfters auf niederem Felde, niemals aber auf dem Gipfel eines Hügels, während *Phellopterus littoralis* überall auf den Dünen verbreitet ist. Diesen Pflanzen folgen zwei kriechende Pflanzen *Lactuca repens* und *Calystegia Soldanella* (Taf. I, Fig. 2).

Am Rande des Sandfeldes, welches einen Übergang von welligem Dünenfelde zu befestigtem bildet, finden sich *Pinus Thunbergii* und *Juniperus rigida*, letztere ein der Sandüberstäubung gut widerstehender Strauch, ferner *Linaria japonica*, *Fimbristylis sericea* und *Artemisia annua* in Gemeinschaft mit den oben erwähnten

1) REINKE nennt solchen Sandhügel, welches ein niemals grösser werdender Hügel ist, „Sandpolster“; er unterschied „Sandpolster“ von „Horst“, welcher eine Anlage von Dünen bedeutet

Pflanzen. Diese verschiedenen Pflanzen zusammen bilden öfters einen niedrigen, befestigten Sandhügel.

Zwischen Dünenfeld und Walddünen liegt eine ganz befestigte Zone, wo die Pflanzen wenig Gefahr laufen, mit Sand überschüttet zu werden. *Juniperus rigida* und *Pinus Thunbergii* sind hier die bedeutendsten Pflanzen. Während die erstere sich durch kriechende Zweige ausdehnt, vermehrt sich die letztere durch viele Keimlinge. *Elaeagnus fragrans* stellenweise *Salix purpurea* subsp. *eupurpurea* var. *sericea* sind weniger bedeutende Sträucher. Die auf den Walddünen überwiegende *Imperata arundinacea* und die ihr zuge-sellten Pflanzen gedeihen hier auch gut.

Im Anschluss an dieses Kapitel möchte ich auf auffallende Sandhügel im Sandfelde aufmerksam machen. Wie Fig. 5 und 6 (Taf. I) zeigen, stehen diese kugel- und halbkreisförmigen Sandhügel stellenweise im weit ausgedehnten Sandfelde. Sie lassen sich durch ihre Componenten in zwei ganz verschiedene Typen einteilen:

Der eine erhebt sich kugelförmig in der Mitte des Feldes und besteht aus dunkelgrünen Sträuchern von *Juniperus rigida*. Dieser Hügel ist ca 2 m. in Höhe und 2–3 m. in Breite und ist gewöhnlich nur mit *Juniperus rigida* bedeckt, selten aber mit *Calystegia Soldanella* und *Linaria japonica* an seinem Abhang bewachsen. Der andere halbkreisförmige Hügel wird durch *Elaeagnus fragrans* gebildet und befindet sich meist auf etwas befestigtem Dünenfelde. Dieser Sandhügel ist grösser als der vorherige, und seine Breite erreicht 6 m. oder darüber, und die Höhe 2–3 m. Seine Componenten sind nicht so einfach wie die des *Juniperus*-Hügels, da *Elaeagnus*-pflanzen durch seine dicht ausgewachsenen Sprösslinge zunächst einen schirmartigen Schutz gegen das Eindringen allzu-starken Lichtes bildet. In solchem Busch gedeihen daher sogar



die Binnenlandgewächse, wie z. B. *Erigeron linifolius*, die trotz ihrer grossen Vermehrungsfähigkeit nie in beweglichen Dünen wachsen.

Ausser diesen Sträuchern sehen wir in diesem Dünenfelde drei Gewächse vereinzelt oder zusammen wachsen, namentlich *Pinus Thunbergii*, *Sarix purpurea* var. und *Alnus japonica*.

### Zusammenfassung.

1. Nach der geographischen Verbreitung der Dünenpflanzen werden die Ōta Dünen in vier Vereinsklassen eingeteilt: Sandstrand, weisse Dünen, Sandfeld und Walddünen.

2. Der Sandstrand liegt längs der Kashimasee im Stillen Ozean. Die psammophilen Halophyten und Psammophyten sind hier vertreten. Von den ersteren ist *Wedelia prostrata* am auffallendsten, andere eigentümliche Pflanzen sind *Ischaemum anthephoroides*, *Phellopterus littoralis*, *Carex macrocephala*, *C. pumila* etc.

3. Die mit Kiefern (*Pinus Thunbergii*) bewachsenen Walddünen befinden sich in der Umgebung des Sandfeldes. Ein Teil dieses Waldes ist schon bebaut. Daher haben sich viele Binnenlandgewächse dort angesiedelt.

4. Weisse Dünen und Sandfelder (Dünenfelder) sind die wesentlichen Bestandteile der Ōta Dünen. Echte Psammophyten überwiegen hier.

5. Diese beiden Vereinsklassen sind auch in drei Kategorien einzuteilen, nämlich in die Gipfel der Dünenhügel, das niedrige Sandfeld und das flache Sandfeld.

6. *Carex macrocephala* bildet fast die einzige Formation auf dem Gipfel des Sandhügels, und zwar ist sie der erste Ansiedler auf den beweglichen Dünen. *Phellopterus littoralis* gesellt sich ihr stellenweise bei.

7. Auf niedriger, feuchter Fläche ist *Carex pumila* vor-



herrschend, *Ischaemum anthephoroides*, *I. muticum* und *Phellopterus littoralis* sind nicht selten.

8. Die Ōta Dünen bestehen grösstenteils aus flachem Sandfelde. Hier kommen viele Psammophyten vor. *Phellopterus littoralis* und *Ischaemum anthephoroides* sind zwei wichtige Pflanzen. *Lactuca repens* und *Calystegia Soldanella* kommen an nächster, und *Ischaemum muticum*, *Artemisia annua* und *Fimbristylis sericea* an dritter Stelle.

9. Die Sandhügel des Dünenfeldes sind von zweierlei Typen; der erste wird durch *Juniperus rigida* und der zweite durch *Elaeagnus fragrans* gebildet. Beide sind in den Ōta Dünen vorherrschend.

## V. Art und Weise der Vermehrung der Dünenpflanzen.

Mit Ausnahme einiger einjähriger Gewächse, können die Dünenpflanzen von Ōta durch Rhizome oder Wurzeln viele Jahre hindurch bestehen, wenn auch ihre oberirdischen Teile im Winter zu Grunde gehen. Diese Kenntnis ist wichtig, wenn man Versuche über die Vermehrungsweise der Dünenpflanzen anstellen will.

Im allgemeinen erfolgt die Vermehrung sowohl geschlechtlich als auch vegetativ. Die geschlechtliche Fortpflanzung scheint bei allen Dünenpflanzen zu erfolgen, weil selbst die zur Vermehrung durch Rhizome befähigten Dünenpflanzen im Sommer oder Frühherbste mit vollkommenen Früchten versehen sind. Obwohl alle Rhizompflanzen Früchte tragen, so sind letztere doch, meiner Beobachtung nach, entweder in nur geringerer Anzahl vorhanden (wie *Carex macrocephala* besonders *C. pumila*) oder sie kommen, im Vergleich mit den unter anderen Umständen wachsenden Pflanzen, in schlechterer Beschaffenheit vor (wie *Lactuca repens* und

*Calystegia Soldanella*).

In den Dünen vollenden die Früchte ihre Fruchtbildung im Sommer, streuen ihre Samen vor dem Eintritt des ausdörrenden Winters aus und keimen im nächsten Frühling. Im Frühling suchte ich nach ihren Keimlingen in verschiedenen Dünen, fand aber nur wenige Keimlinge der Rhizompflanzen und fast keine *Carex*-Keimlinge, sogar in *Carex*-Formation, obgleich viele Samen dort ausgestreut worden sein müssen. Es ist auch nennenswert, dass ich jungen, d. h. zwei oder drei jährigen *Carex*-Arten, weder auf den Ōta Dünen noch auf den Stranddünen, wo sie ihre günstige Stelle finden, begegnet bin. Wenn auch ein genaues Experiment noch nicht ausgeführt worden ist, so kann man doch aus obigen Beobachtungen annehmen, dass die beiden erwähnten *Carex*-Arten und *Ischemum muticum* sich hauptsächlich auf ungeschlechtlichem Wege vermehren. Die Samen solcher Pflanzen können zwar auf dem Sandboden keimen, aber die Keimlinge wachsen in den Dünen doch nicht immer aus.

Unter den sich durch Samen vermehrenden Pflanzen ist *Phellopterus littoralis* bemerkenswert. Im Frühsommer schmückten sie ihre Krone mit vielen Blüten, und ihre Früchte verbreiten sich im Hochsommer in der Nähe der Mutterpflanze. Öfters wird ihre Inflorescenz nach der Befruchtung mit Sand bedeckt, und aus dem Herde der reifen Früchte kommen im nächsten Frühling zahlreiche Keimlinge hervor.

Zwecks weiterer Beobachtung über die Keimungsfähigkeit der Samen von Dünenpflanzen sähte ich verschiedene Samen, die ich im Sommer 1915 in den Ōta Dünen gesammelt hatte, aus. Am 24. September begann ich mit *Carex macrocephala* und *Phellopterus littoralis*, wobei ich die mit Sand gefüllten, besäten Töpfe im Freien aufstellte. Kein Same keimte vor Anfang April, doch

fingen sie dann alle gleichzeitig zu keimen an. Von 150 Samen von *Phellopterus* und 200 Samen von *Carex* erhielt ich 122 (80%) resp. 56 (28%) Keimlinge. Demgemäss haben die *Carex*-Samen im Sandboden zweifellos Keimfähigkeit, wenn sie auch im Vergleich mit *Phellopterus*-Samen schwach sind. Alsdann säte ich am 18. August frisch geerntete Samen von *Phellopterus littoralis*, *Lactuca repens* und *Calystegia Saldanella* und am 26. Dezember *Juniperus rigida* in den Ōta Dünen in verschiedenen Tiefen aus. Am Ende April keimten die Samen von *Phellopterus*, *Lactuca* und *Calystegia* in 1, 4 und 7 cm. Tiefe, aber nicht in 10 cm. Tiefe. *Juniperus*-Samen zeigten im Sommer 1916 noch keine Keimlinge.

Es ist ferner eine bedeutende Frage, ob die Samen bei der Vermehrung von entscheidender Wichtigkeit seien oder nicht. Zweifellos ist jedoch, dass sich wichtige Dünenpflanzen hauptsächlich nicht durch Samen vermehren. Dies rührt nicht von dem Verlust der Keimfähigkeit der Samen her, sondern ist grossenteils auf die Unmöglichkeit der Keimlinge, unter solch ungünstigen Umständen zu wachsen, zurückzuführen. Daher möchte ich im folgenden die vegetative Fortpflanzung der Dünenpflanzen, einschliesslich ihrer Formen, näher betrachten.

Im lockeren Sandboden wird das Wachstum der Rhizome weit weniger gehindert als in irgend einem anderen; deshalb kriechen sie leicht mit zugespitzten Endknospen im Sande umher, indem sie dort gleichzeitig ihre Wurzeln festigen. Bei *Lactuca repens* und *Calystegia Soldanella* stirbt allmählich der ältere Teil des Rhizoms ab, während letzteres in immer verjüngter Form neu aussprosst. Anders verhält es sich bei *Carex*-Arten und *Ischaemum muticum*. Bei diesen bleiben die älteren Teile der Rhizome noch längere Zeit, ja öfters noch viele Jahre, erhalten, und die auf jedem Knoten entwickelten Wurzeln dienen zur Festigung der weit ausgestreck-

ten Rhizome; daher finden wir bei diesen Pflanzen die weit verbreitetsten Rhizome.

Ich will hier die Eigenschaften der vegetativen Fortpflanzungsorgane und die Vermehrungsweise, sowie Vermehrungsgeschwindigkeit der zur Dünenbefestigung wichtigsten Pflanzen beschreiben. Alle Beobachtungen und Versuche wurden im Naturzustande, hauptsächlich auf den Ōta Dünen im Sommer, Winter 1915 und Frühling 1916 ausgeführt.

1. *Lactuca repens* BENTH.

Das Rhizom kriecht in der Tiefe von 5–15 cm. fort, und seine Länge schwankt im allgemeinen zwischen 1–1.5 m.; das längste geht nicht über 2 m., da die älteren Teile allmählich absterben und die jüngeren sich von der Mutterpflanze trennen. Das Rhizom verzweigt sich selten; gewöhnlich erstreckt es sich in horizontaler Richtung. Die Länge des Internodiums ist durchschnittlich 4.7 cm.<sup>1)</sup> An beiden Seiten des Blattstiels entspringen aus jedem Knoten zwei Wurzeln, die als Wassersauger und zur Befestigung dienen.

In Bezug auf Wachstumsgeschwindigkeit werde ich einige Beispiele zeigen:

Vers. 5. Ein 134 cm. langes Rhizom, dessen Internodien von der Spitze zum Grunde je folgende Längen betragen: 0.9, 4.2, 4.6, 6.0 cm. etc. An dem sechsten Knoten (von der Spitze) erst finden wir ein auf dem Boden hervorgetriebenes Blatt.

Vom Sommer bis zum Winter (August–Dezember) verlängerte es sich um 90 cm. (A). Aus dem fünften (B) und sechsten (C) Knoten (das Rhizom war an der Stelle zwischen dem vierten und fünften Knoten entzweigeschnitten worden) sprossen zwei Seitentriebe von 71 bzw. 79 cm. Länge in der Richtung der Mutterpflanze aus.

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1) Sie wurde bei zehn ausgewachsenen Rhizomen gemessen.

Vom Winter bis zum Frühling (Dezember–April). Während der spitze Hauptteil (das Rhizom war 42 cm. von der Spitze entfernt abgeschnitten worden) sich um 26 cm. verlängerte, brachte der Grundteil einen neuen, 105 cm. langen Seitentrieb hervor. (B) und (C) verlängerten sich um 31 cm. bzw. 45 cm.; ausserdem sprossste am elften Knoten ein neuer Trieb von 20 cm. Länge heraus.

Andere Beispiele zeigten, dass ein Rhizom im Herbste zwei Seitensprossen in Länge von 78 cm. und 67 cm. ausgetrieben hatte, während diese beiden im Herbste sich um 38 cm. bzw. 31 cm. verlängerten.

Andere Versuche stimmten darin überein, dass die Verlängerung der Rhizome im Frühling (Jan. bis Apr.) fast die Hälfte oder zwei Drittel der Verlängerung im Herbst (Sept. bis Dez.) betrug.

## 2. *Calystegia Soldanella* R. Br.

Das Rhizom kriecht nahe unter der Oberfläche fort (10–20 cm. Tiefe), und erreicht öfters eine Länge von annähernd 10 m.

Nach Messungen in den Ōta Dünen zeigt die Länge desselben durchschnittlich 6–8 m.; auf dem Strandsand zu Misaki und den weissen Dünen zu Kugenuma fand ich aber einige Rhizome, die über 10 m. erreicht hatten. Die ältesten Grundteile verwandelten sich öfters in holzartige Stämme. Wie bei *Lactuca repens*, trennen sich die jüngeren Teile leicht von der Mutterpflanze, besonders dann, wenn ein Teil auf dem Sande ausgesetzt wird.

Die Länge des Internodiums ist nicht so regelmässig wie die der *Lactuca repens*; je näher es dem Wurzelstock liegt, desto kürzer wird es, und es erreicht an dem ausgewachsenen Triebe eine Länge von 8–12 cm. Auf der Seite der Knospen entstehen zwei kräftige Wurzeln, die mehr zur Wasserzufuhr dienen.

Das Rhizom wächst besonders im Herbst, während es im Frühling beinahe keine Verlängerung zeigt. Nur im Frühling richtet sich die Spitze nach der Oberfläche.



3. *Carex macrocephala* WILLD.

Die unter der Tiefe von 20–40 cm. wagerecht kriechenden Rhizome nehmen überraschend grossen Raum ein, wie aus nachstehenden Beispiel zu ersehen ist.

Eine einzelne Pflanze wurde im Sommer (am 22. Juli 1915) am Gipfel einer ungefähr 20 m. hohen Düne gemessen. Sie breitete sich über einen Raum von ca. 60 q. m. aus, wie aus Fig. 3 einleuchtet, und die Gesamtlänge des Rhizoms erreichte wohl mehr als 80 m.<sup>1)</sup> Es ist

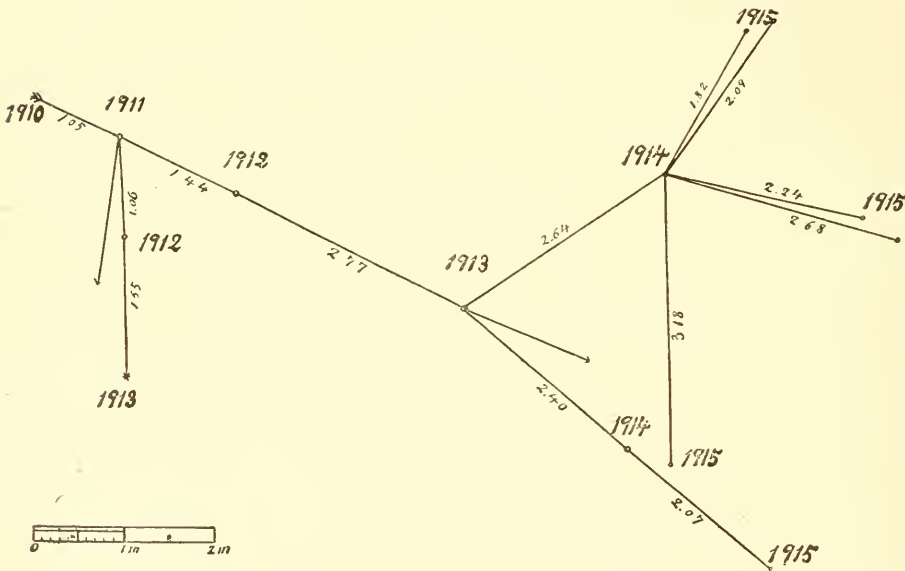


Fig. 3.—Der Zustand des Rhizoms von *Carex macrocephala* auf einem Sandhügel im Sommer 1915.

Die Abbildung zeigt den Zustand des horizontal kriechenden Rhizoms einer ausgewachsenen Pflanze. Besondere Aufmerksamkeit wurde seiner Länge, Richtung und seinen Entwicklungsjahren zugewandt. (Zahl in Metern.)

N.B. Laubspalten wurden durch Punkte bezeichnet. Der Pfeil zeigt die Stelle, wo das Rhizom natürlich abgeschnitten war. Die mit \* bezeichnete Stelle wurde bei Ausgraben abgeschnitten, und seine Spitze war unsichtbar.

1) Obwohl ich beim Ausgraben besonders Sorge trug, verlor ich einige Seitenausläufer; auch ist es bemerkenswert, dass die angegebene Ziffer die jungen noch im Entwicklungszustande befindlichen Sprossen nicht enthält.



ein vieljähriges Gewächs, welches sich in den zwei letzteren Jahren vielleicht um 20 m. verlängert haben dürfte.

Die Länge des Internodiums ist ca. 5 cm.<sup>1)</sup>, und die Länge zwischen den Laubsprossen schwankt in vielen Fällen zwischen 4 und 6 m. Bezüglich der Wachstumsgeschwindigkeit des Rhizoms besitze ich keine genauen Daten über Versuche im Freien, aber es ist kaum zweifelhaft, dass das Rhizom auch im Herbste sich stark verlängert. Ich richtete besondere Aufmerksamkeit auf die Zahl und die Länge der unterirdischen Sprossen. Wenn auch jeder Laubstengel an seinem verkürzten unterirdischen Stamme immer mit vielen Sprossen versehen ist, so finden sich lange, ausgeprägte Ausläufersprossen, jedoch nur nach dem Herbste, vor.<sup>2)</sup>

#### 4. *Carex pumila* THUNB.

Diese Pflanze schliesst sich an vorgehende Art an, doch unterscheidet sie sich von der letzteren durch das Gedeihen auf feuchtem Boden. Demgemäss kriechen die Rhizome in tieferen Schichten von ca. 30 cm. oder manchmal sogar über 40 cm. Tiefe fort.

Während ein unterirdischer Spross sich im Herbste um 82 cm. verlängert, zeigt er doch nach vier Monaten (von Januar bis April) beinahe keine Verlängerung, aber seine Spitze beugt sich aufwärts und entwickelt sich zum Laubsprosse.

In welchem hervorragenden Masse diese Pflanze in den Dünen sich entwickelt, zeigen die nachstehenden ausführlichen Abbildungen (Fig. 4, *a* und *b*) von zwei am 14. August 1915 in den Ōta Dünen gemessenen Pflanzen.

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1) Wie in der nächsten Abteilung erwähnt, nimmt die Länge des Internodiums natürlich stark zu, wenn das Gewächs bei Sandüberstäubung abwärts zu wachsen strebt.

2) Ich beobachtete, z. B., im Anfang März, auf den Kugenuma Stranddünen eine *Carex macrocephala*, die in dieser frühen Zeit schon sieben (110, 100, 64, 44, 30, 19 und 17 cm. Länge) Sprossen ausgetrieben hatte.

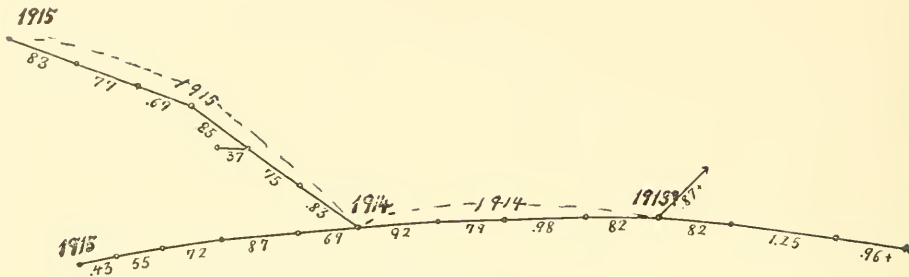


Fig. 4. a.

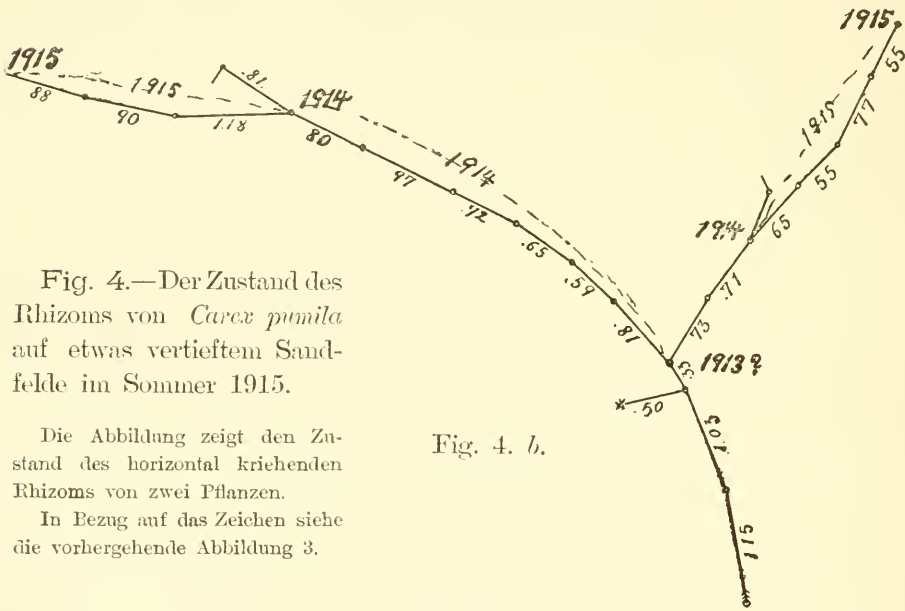


Fig. 4. b.

Fig. 4.—Der Zustand des Rhizoms von *Carex pumila* auf etwas vertieftem Sandfelde im Sommer 1915.

Die Abbildung zeigt den Zustand des horizontal kriechenden Rhizoms von zwei Pflanzen.

In Bezug auf das Zeichen siehe die vorhergehende Abbildung 3.

##### 5. *Ischaemum muticum* L. (= *Zoysia macrostachya* Fr. et Sav.)

Sie stellt kein so langes Rhizom wie die vorhergehenden *Carex*-Arten dar. Im allgemeinen ist die Länge des unterirdischen Stengels 2–3 m. Mit zugespitzten Endknospen durchläuft das Rhizom den Sandboden in gerader Linie in Tiefe von 20–30 cm. Zwei hauptsächlich zur Festigung dienende Wurzeln, welche jeder Knoten liefert, verlaufen in einem spitzen Winkel zueinander, und reichen schräg in den Boden über 60 cm. hinein. Es ist nennenswert, dass bei dieser Pflanze der Vegetationspunkt der Laub-

sprossen in den vertrockneten Blättern zurückbleibt und sich wieder im nächsten Frühling zu entwickeln anfängt.

Ein Rhizom, welches sich vom Sommer bis Winter um 51 cm. Länge mit 12 neuen Internodien verlängert hatte, zeigte fast kein Wachstum in der Frühlingszeit (vom Dezember bis April), aber entfaltete einen Laubspross an der Spitze.

#### 6. *Ischaemum antheperoides* MIQ.

Dieses Gras besteht aus dicht am Grunde verzweigten Stengeln, dessen Zahl öfters mehr als 30 beträgt. An jedem Knoten entwickelt sich ein Laubspross; daher kann sich diese Pflanze dicht verzweigen und einen kleinen Busch bilden. Die unter dem Sande bleibende Sprossanlage aber entfaltet sich nicht bis zur nächsten Frühlingszeit; dann tritt sie an die Stelle der alten Stengel. Jeder Knoten im Boden trägt einige (gewöhnlich 2), fast horizontal laufende Wurzeln, die zur Befestigung des Stengels dienen. Da auf diese Weise ein Stengel nicht selten 4–6 Wurzeln trägt, so hat ein ausgewachsenes Individuum fast einhundert Wurzeln; man kann sich deshalb leicht vorstellen, wie stark diese Pflanze im lockeren Sandboden befestigt ist. Die Wurzel erreicht gewöhnlich 1–1.5 m., aber bei Kugenuma fand ich eine Wurzel, die eine Länge von beinahe 2 m. (1.93 m.) erreicht hatte.

Das Netzwerk der *Ischaemum*-Wurzeln liegt nicht so tief, wie man vermutet; es befindet sich in einer Tiefe von ca. 10 cm., und schon bei 20 cm. sehen wir kaum seine Wurzeln mehr. Im Gegensatz zu *Ischaemum muticum* geht der Vegetationspunkt am Stengel im Winter zugrunde.

#### 7. *Phellopterus littoralis* BENTH.

*Phellopterus* steht einzeln im Sandboden, dessen Wurzelstock und Wurzel in vertikaler Richtung in die Tiefe gehen. Jeder ver-

kürzte Wurzelstock hat viele schlafende Sprossen an den Achseln der vorjährigen Blattstiele. Die vergleichende Länge zwischen Wurzelstock und Wurzel ist unregelmässig, da sich die Länge des unterirdischen Stengels je nach den Sandschüttungen oder den Freilegungen verändert. Aber die Länge des Wurzelstocks und die der Wurzel zusammen schwanken ungefähr zwischen 50–60 cm.; und ihre Dicke geht selten über 3 cm. hinaus. Es ist auffallend, dass sich am Wurzelstock viele Achselknospen und an den zylindrischen Hauptwurzeln viele adventive Knospen befinden. Sie entwickeln sich nur nach Ablösung der oberirdischen Teile im Herbst, wenn die Früchte schon reif sind. Die Eigenschaften dieser Pflanze werden in den Abteilungen VI und VII weiter ausführlich beschrieben.

8. *Fimbristylis sericea* R. BR.

Bei dieser kleinen Pflanze ist es bemerkenswert, dass sich ein ausgeprägter Unterschied zwischen Zug- und Nährwurzel darstellen lässt. Erstere ist sehr dünn und lang, und erreicht nicht selten einen Meter. Diese feinen Wurzeln drängen sich immer nach einer Seite hin zusammen und dienen als Befestigung für ihre Sprossen. Die frische, kurze Nährwurzel dagegen verbreitet sich nach allen Seiten und sorgt für Wasser- und Nährstoff.

9. *Artemisia annua* L.

Diese ist eine mit verkürztem Wurzelstock überwinternde Pflanze. Viele reichverzweigte Wurzeln dringen schräg tief in den Sand hinein.

10. *Juniperus rigida* S. et Z., *Elaeagnus fragrans* NAKAI und *Pinus Thunbergii* PARL.

Obwohl diese Pflanzen für die Dünenbefestigung eine grosse Rolle spielen, so stellte ich doch, wegen der Schwierigkeit der

Messungen im Flugsande, keine besonderen Versuche bezüglich der Länge der Wurzeln und anderer Eigenschaften an.

### Zusammenfassung.

1. Die wichtigen Dünenpflanzen vermehren sich hauptsächlich durch Rhizome. Wenige Keimlinge der Dünenpflanzen können unter derartigen ungünstigen Bedingungen auswachsen. *Phellopterus littoralis* ist die einzige, sich durch Samen vermehrende Pflanze.

2. Bemerkenswert ist es, dass sich die unterirdischen Organe fast das ganze Jahr hindurch entwickeln, dass aber das Wachstum besonders nach der Fruchtzeit vor sich geht. Diese Wachstumsenergie wird im Frühling zur Neubildung von Laub- und Blüten sprossen verbraucht.

3. Das Netzwerk von Wurzeln und Rhizomen im Sandboden liegt nicht so tief, wie man glauben könnte. In der Tiefe von einem halben Meter schon sehen wir mit Ausnahme der vertical gehenden *Phellopterus*-Wurzel, fast keine unterirdischen Organe.

4. Die Tiefe und Länge der Rhizome und Wurzeln der wichtigen Dünenpflanzen sind in folgender Tabelle zusammengefasst:

TABELLE IV.

Tiefe und Länge der unterirdischen Organe der wichtigen Dünenpflanzen.

Namen der Pflanzen	Tiefe des Rhizoms cm.	Länge des Rhizoms m.	Länge des Internodiums cm.
<i>Carex macrocephala</i> .....	20—30	10—15	4—6
<i>Carex pumila</i> .....	30—50	10—15	2—5
<i>Ischaemum multicum</i> .....	20—30	2— 3	6—10
<i>Lachua repens</i> ... ..	5—20	1.5— 2	3—8
<i>Calystegia Soldanella</i> .....	10—20	7—10	8—12

Namen der Pflanzen	Tiefe der Wurzel cm.	Länge der Wurzel m.	
<i>Ischaemum anthephoroïdes</i> . . .	10—20	0.5—2	—
<i>Fimbristylis sericea</i> . . . . .	30—60	0.5—1	—
<i>Phellopterus littoralis</i> . . . . .	50—60	0.5—0.6	—

Es ist bemerkbar, dass die Länge des Internodiums nicht bestimmt ist, besonders wenn das Gewächs durch Sand bedeckt oder frei gelegt ist.

## VI. Widerstandsfähigkeit der Dünenpflanzen gegen Sandüberstäubung.

Es ist eine bekannte Tatsache, dass die Dünenpflanzen, und zwar besonders die auf den beweglichen Dünen wachsenden, die Sandbedeckung ertragen müssen<sup>1)</sup>.

Im folgenden werde ich das Verhalten einiger Dünenpflanzen gegen Sandverschüttung beschreiben :

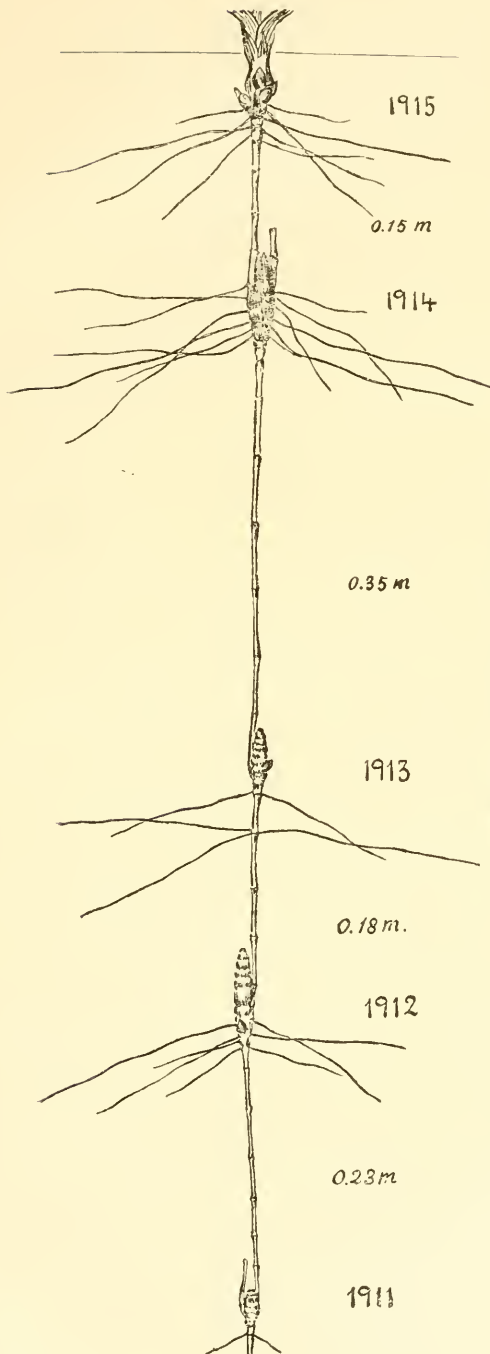
### 1. *Carex macrocephala*.

Die horizontal ausgebreiteten Erdstengel bringen an den begünstigsten Stellen Laubsprossen hervor. Diese Sprossen haben nach einigen Jahren noch die Fähigkeit, neue Laub- oder Rhizomsprossen aus ihren verkürzten, unterirdischen Stämmen zu treiben.

Der Sandflug fängt sich hinter diesen Blätterbüscheln, und eine teilweise allmähliche Verschüttung findet statt. Letztere kommt hauptsächlich im Winter vor, wenn der starke Wind den ausgetrockneten Sand fortweht. Hierdurch wird die auf dem Stammknoten schlafende Sprossanlage durch die Sandbedeckung nicht in horizontaler Richtung, sondern nach oben getrieben. Gleichzeitig entwickeln sich viele Wurzeln auf und nahe an dem Knoten, welche

1) WARMING, E.: 1900. l.c. p. 264.  
COWLES, H.: 1899. l.c. p. 177.



Fig. 5.—*Carex macrocephala*.

Ein auf primärer *Carex*-Düne bei Kugemma gerontes Gewächs. Wegen Sandüberstäubung erstreckte es sich aufwärts; jeder Stammknollen zeigte die Höhe der Düne der vorhergegangenen Jahre.

zur Befestigung des neu gebildeten Laub-sprosses dienen. Wiederholt sich die Sand-überstäubung, so setzen die Sprossen das Wachstum in senk-rechter Richtung fort. Infolgedessen erlöhnt sich die Sanderhebung, bis eine Dünenanlage zustande kommt. Wir beobachten solche Dünenanlagen öfters auf dem Strandsande, wo der Wind stark und folglich die Sand-bedeckung lebhaft ist. Fig. 5 stellt ein solches Gras dar, welches an den vertikalen Auf-schlüssen einer Dünen-anlage ausgegraben wurde. Wie vier untere Stammknollen zeigen, hat jeder der-selben zu einer Zeit an der Oberfläche einen Blätterbüschel hervorgebracht.

2. *Carex pumila*.

Sie kommt an etwas feuchten Stellen vor. Deshalb wird sie selten mit Flugsand überschüttet, selbst wenn sie mit Wasser oder mit dem beim Hochwasser beladenen Humus bedeckt wird. Demgemäss bildet sie im Gegensatz zu der vorhergehenden, verwandten Pflanze keine Dünenanlage, sondern dient zur Befestigung des Sandbodens an niederen Stellen.

Öfters sah ich sie am Dünenhange hervorwachsen; in solchem Falle verlängerte sich der unterirdische Stengel aufwärts um einen halben Meter.

3. *Ischaemum antheplhoroides*.

Da dieses Gras nicht mit Rhizomen versehen ist, fehlt es an Dünenbildungsfähigkeit, aber, wie ich schon erwähnte, bilden seine dicht verwachsenen Sprossbüschel ein kleines Sandpolster auf dem Dünenfelde. Es kann im Sandboden längere Zeit nach der Sandverschüttung leben. Gewöhnlich entwickelt sich im Frühling die unterirdische Achselknospe des vorigen Laubstengels, aber in dem Falle der Sandbedeckung verhält es sich ganz anders. Hierbei entwickeln sich, anstatt der unteren Achselknospe, die auf den oberen Knoten liegenden Knospen, welche, wenn nicht mit Sand überschüttet, mit dem Absterben des Mutterstengels zugrunde gehen. Fig. 10 (Taf. II) zeigt dieses Verhältnis. Man hat auch gesehen, dass die Entwicklung der Wurzeln in solchem Falle den Sprosstrieben vorangeht.

Also wirkt die Überschüttung mit Flugsand im Winter auf diese Pflanzen sehr günstig ein und keinesfalls ist sie von schädlichem Einfluss. Dessenungeachtet finden wir auf den Dünen nur selten ein sandüberschüttetes *Ischaemum antheplhoroides*. Der Grund hierfür ist, dass im Winter, wenn die fruchtbare Bewegung des Flugsandes stattfindet, die oberirdischen Teile dieser Pflanze ganz abgestorben

sind, und sie dem Flugsande weniger Widerstand leisten kann.

#### 4. *Phellopterus littoralis*.

Diese Pflanze eignet sich besonders gut für bewegliche Dünen. An dem unter Sand begrabenen verkürzten Stengel gibt es, wie schon erwähnt, viele Sprossanlagen, die im Falle der Verletzung des Laubsprosses an seine Stelle treten.

Wenn diese Pflanze nach ihrer Reifezeit von Flugsand begraben wird, so beginnt, da der Laubspross dann schon Entwicklungsfähigkeit verloren hat, eine ruhende Knospe, besonders die der Oberfläche am nächsten liegende, sich ohne weiters durch die Sandbedeckung zu entwickeln. Sobald sie die Sandoberfläche erreicht, entfaltet sie sich, und ihre Blätter nehmen Assimilation an.

Ich fand ein Beispiel im October 1915 bei den Kugenuma Stranddünen, wo aus Anlass des Manövers ein Graben nach der Blütezeit (vielleicht im Spätsommer) angelegt und der Sand ringsumher aufgehäuft worden war. Infolgedessen waren viele *Phellopterus littoralis* durch die Sandmasse mit einer Schicht von ca. 50 cm. überschüttet worden, und schon im October zeigte sich ein verlängerter Spross einer ruhenden Knospe an der Oberfläche (Taf. II, Fig. 9).

Andere Versuche wurden auch auf den Ōta Dünen wiederholt angestellt, welche an anderer Stelle beschrieben werden. Diese zeigen auch starke Widerstandsfähigkeit gegen Sandüberstäubung.

#### 5. *Lactuca repens*.

Der längste Blattstiel ist, soweit ich fand, nicht über 25 cm.<sup>1)</sup> Diese Tatsache zeigt, dass er sich in tiefer Sandbedeckung nicht unbeschränkt verlängern kann. In solchem Falle wächst das Rhizom, anstatt des Blattstiels, zuerst schiefsteigend, und wenn es

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1) Der längste, den ich im Naturzustande beobachtet habe, war 23 cm.; er wurde am Abhang kleiner Stranddünen zu Onjiku, Kazusa, im Winter 1915 gefunden.

eine günstige Tiefe erreicht hat, dann fängt es wieder horizontal zu laufen an, indem sich einige Blattstiele vom Rhizom aus erstrecken. Aber wenn plötzlich Sandüberstäubung stattfindet (wie z. B. diese Pflanze am Dünenhang im Winter von Flugsand ganz bedeckt wird), ergibt sich ein anderes Verhältnis, nämlich eine ruhende Knospe entwickelt sich auf der Blattstielachsel und strebt senkrecht aufwärts der Oberfläche zu. Einige Beispiele fand ich auf verschiedenen Dünen.

6. *Calystegia Soldanella*.

Sie verhält sich sehr ähnlich wie die vorhergehende Art in Bezug auf Sandbedeckung. Ich beschreibe auf Fig. 11 (Taf. II) ein Beispiel, bei welchem ein senkrecht aufsteigender Laubspross von 40 cm. Länge aus einer ruhenden Achselknospe stammt.

7. *Ischaemum muticum* (= *Zoysia macrostachya*).

Da diese Pflanze gewöhnlich an feuchten oder festen Stellen vorkommt und nur kleine Laubsprossen hat, spielt sie keine wichtige Rolle in Bezug auf Sandhäufung. Aus ihrer Struktur aber ist es begreiflich, dass diese Pflanze gegen Sandüberstäubung starke Widerstandsfähigkeit hat. Wenn sie mit Sand überschüttet wird, verhält sie sich ganz anders als *Ischaemum anthephoroides*. Da der Stengel eine Beschaffenheit hat, sich immer nach oben zu verlängern, so nimmt er mit der Höhe des Flugsandes zu, und gleichzeitig hat jeder Knoten die Fähigkeit, zwei Wurzeln zur Befestigung des Stengels auszutreiben.

8. *Juniperus rigida*.

Dieser Strauch ist eine wichtige Pflanze zur Befestigung der Dünen. Je mehr er mit Flugsand verschüttet wird, desto mehr verbreiten sich die oberen Zweige, indem auch die unteren verschütteten Zweige lange Zeit nicht absterben. Diese weit verbreiteten und dicht verzweigten Äste erweisen sich als Gerüst der

Flugsandhäufung. Auf diese Weise wird der auffallende Sandhügel auf dem Dünenfelde geformt.

9. *Elæagnus fragrans* (= *E. pungens* var. *rotundata*).

Diese Pflanze ist ein anderer Sandhügel bildender Strauch und hat auch starke Widerstandsfähigkeit gegen Sandbedeckung. Der Vorgang der Sandhügelbildung ist in der Hauptsache dem des *Juniperus rigida* gleich, es ist aber nennenswert, dass der *Elæagnus*-Hügel sich auf festerem Sandfelde als der des *Juniperus* bildet.

10. *Pinus Thunbergii*.

Wie aus Fig. 2 (Taf. 1) wohl einleuchtend ist, sind ausgewachsene Bäume ziemlich stark gegen Sandbedeckung, aber ihre Keimlinge können sich fast unter der Flugsandhäufung nicht erhalten.

### Zusammenfassung.

1. Alle Dünenpflanzen haben Widerstandsfähigkeit gegen Sandüberstäubung, und sie werden im Sande lange Zeit gut geschützt.

2. Das Verhalten der Dünenpflanzen gegen Sandbedeckung ist verschiedenartig: *Carex macrocephala* besitzt die günstige Eigenschaft, Sanderhebungen zu bilden. Wird sie vom Flugsand überschüttet, so erstrecken sich die Rhizomspossen nicht horizontal sondern vertikal aufwärts und schiessen nach der Oberfläche.

Während bei *Ischaemum anthephoroides* eine auf dem oberen Knoten ruhende Knospe sich entfaltet, verlängert sich der Halm bei *Ischaemum muticum* mit Zunahme der Sandhöhe.

Wenn dagegen *Lactuca repens* und *Calysiegia Soldanella* mit Sand überschüttet werden, so entwickelt sich die ruhende Achselknospe senkrecht aufwärts und fängt in günstiger Höhe an, wieder wagrecht zu laufen.

*Phellopterus littoralis* ist mit anpassender Eigenschaft für Dünen bei Sandbedeckung durch Entfaltung irgend einer von den



vielen auf dem Wurzelstock ruhenden Knospen versehen.

3. Die Widerstandsfähigkeit gegen Sandüberstäubung ist eine wichtige Eigenschaft der echten Dünenpflanzen. Die Ursache, warum die Binnenlandpflanzen nicht in die Dünen eindringen können, ist grösstenteils diesem Umstande zuzuschreiben.

### **Anhang. Ruhezeit der Dünenpflanzen.**

Am Schlusse dieser Abteilung möchte ich die Ruhezeit dieser Dünenpflanzen kurz erörtern.

Im Winter haben die Holzgewächse in unserem Lande eine Ruheperiode, und Gräser und Kräuter oder wenigstens ihre oberirdischen Teile, gehen zugrunde. Bei Anblick der im Winter von feinem Flugsand stark umwehten Dünen und der scheinbar abgestorbenen Vegetation können wir daran zweifeln, ob die Dünenpflanzen im Winter noch von Wichtigkeit für die Befestigung der Dünen sind. Aber bei ausführlicher Beobachtung zeigt es sich, dass die wesentlichen Dünenpflanzen, besonders Rhizompflanzen, im Winter noch kräftige Entwicklungsfähigkeit haben, wenn auch ihre oberirdischen Teile durch niedrige Temperatur, insbesondere von Frösten zerstört werden. Die *Carex*-Arten zeigen hier und da selbst im Winter grüne Blätterbüschel. *Lactuca repens* und *Calyptegia Soldanella* bringen ihre Blätter auf den Ōta Dünen nur an solchen Stellen hervor, wo sie vor Frost geschützt sind, aber sie wuchern wohl an den wärmeren Küsten. *Phellopterus littoralis* verhält sich fast gleich wie *Lactuca repens*, und es ist bemerkenswert, dass die Knospe bei Sandbedeckung zu frischerem Wachstum getrieben wird. Diese ist eine gemeine Eigenschaft der Dünenpflanzen, und man muss ihr besondere Aufmerksamkeit schenken. *Ischaemum anthephoroides* und *Ischaemum muticum* sind ausdauernde Pflanzen, die im Winter fast einen ruhenden Zustand zeigen, aber



beim Kultivieren im Gewächshause entfalten sie sich und können unter günstigen Bedingungen gut gedeihen.

## VII. Widerstandsfähigkeit der Dünenpflanzen gegen Trockenheit.

Wie schon oben besprochen, besitzen alle Dünenpflanzen gegen Sandüberstäubung starke Widerstandsfähigkeit, und somit dient der Sand für solche Pflanzen sogar als Schutzmittel.

Auf welche Ursache ist, dann wohl das Sterben der Dünenpflanzen, das wir besonders im Winter in den Dünen sehen, zurückzuführen?

In dürrender Zeit wird der Dünensand durch Wind weggetrieben, und die Dünenpflanzen sind mit entblössten Wurzeln oder Rhizomen der Austrocknung durch Wind und Sonne ausgesetzt. Daher werden auch die Sprossen, welche sonst unter dem Boden geschützt waren, frei gelegt, und schliesslich geht der Pflanzenstock zugrunde.

### 1. *Carex macrocephala*.

Die durch das Wegtreiben des Sandes hervorgerufene schädigende Wirkung ist bei dieser Rhizompflanze am merkwürdigsten.

Fig. 13 (Taf. II) zeigt diese Pflanze in frei gelegtem Zustand auf einer Düne. Im Dezember vorigen Jahres, nach einem heftigen Sturm auf einer Stranddüne, hatte ich Gelegenheit, viele in dem Sande liegende Erdstengelsprossen von *Carex macrocephala*, die schon eine Länge von einem Meter erreicht hatten, zu beobachten. Man kann leicht wahrnehmen, dass bei solchen Fällen zuerst die jungen Sprossen austrocknen und absterben.

Im heissen Sommer schnitt ich einige Laubsprossen vom Rhizom los. Trotz der Vollkommenheit der Seitenwurzeln fingen bald einige dieser Laubsprossen zu welken an und schliesslich gingen sie zugrunde. Somit kann man das Rhizom nicht nur als Vermehrungsorgan, sondern auch als Wasserspeicherungsorgan betrachten.

2. *Carex pumila*.

Bei dieser Pflanze kommt selten die Gefahr der Trockenheit vor, da sie stets auf feuchten Stellen wuchert. Demgemäss lässt sie sich auch nur selten durch den Wind ausgraben, aber oft wird sie durch Wegspülen des Sandes frei gelegt.

3. *Ischaemum anthephoroides*.

Wegen seiner starken Festigkeit durch die vielen in den oberen Schichten flach hinstreichenden Wurzeln lässt sich dieses Gras selten freilegen. Wenn dies jedoch der Fall ist, so vermag es infolge geringer Verdunstung in ausgetrocknetem Zustande die Aussetzung leicht zu ertragen (Taf. II, Fig. 12).

Im heissen Sommer stellte ich die gleichen Versuche an, wie bei *Carex macrocephala*. Um die Widerstandsfähigkeit dieser Pflanze gegen Trockenheit, unter Berücksichtigung der Wasseraufnahme der Wurzeln, zu sehen, trennte ich einige ausgewachsene Stengel von einander ohne Verletzung der Wurzeln. Ich fand hierbei, dass bei *Ischaemum anthephoroides* jeder mit 2–4 Wurzeln versehene Stengel mit dem Mutterstengel durch den Knoten verbunden ist. Jeder dieser Stengel wurde am 24. Juli 1915 besonders auf drei verschiedene Weisen behandelt und untersucht, nämlich :

- A) Mit Ausnahme von 2 Wurzeln alle abgeschnitten.
- B) Mit Ausnahme von 1 Wurzel alle abgeschnitten.
- C) Mit Ausnahme von 1 Wurzel alle abgeschnitten und dann die übrig bleibende Wurzel bis auf ca. eine Länge von 30 cm. ebenfalls abgeschnitten.

Alsdann dauerten heisse Tage ohne Niederschläge an, worauf ich folgende Wahrnehmung machte :

Während sich bei ersterer Pflanze (A) keine Veränderung zeigte, waren die Blätter der übrigen verwelkt. Aber später erlangten die mit einer vollkommenen Wurzel versehenen Stengel (B) ihren normalen Zustand wieder, während die am Wurzelende abgeschnittenen Stengel (C) schliesslich ganz zugrunde gingen.

Diese Ergebnisse zeigen, wie *Ischaemum anthephoroides* bei Hitze und Trockenheit widerstehen kann, und dass andererseits diejenigen Wurzeln, die sich als zur Befestigung dienende Organe erweisen, für die Wasseraufnahme eine wichtige Rolle spielen.

#### 4. *Lactuca repens*.

Obwohl *Lactuca*-Rhizome in tiefe Schichten nicht eindringen, werden sie sehr selten ausgegraben. Aber wenn sie einmal freigelegt sind, so färben sich alsbald die weissen Teile rot, und brechen dann an dieser Stelle ab. Wird die Spitze des Rhizoms ausgegraben, so ist der Vorgang beachtenswert. Zuerst verkürzen sich die nach Freilegung geformten Internodien, während die Anzahl der Knoten bedeutend zunimmt. Alle diese Knoten treiben Blätter aus, und infolgedessen sieht das Rhizom dann wie ein oberirdischer Laubspross aus.

Um die Regenerationsfähigkeit und Widerstandsfähigkeit gegen Trockenheit zu sehen, hatte ich im Sommer und Winter das Rhizom in verschiedener Länge zerschnitten, ohne die Wurzel zu verletzen.

Die ausführlichen Resultate werden nachher in dem Kapitel über Regeneration erwähnt. Ich möchte an dieser Stelle nur bemerken, dass bei den Rhizomstücken, welche mit einem einzigen Knoten bzw. einem Blatt versehen sind, das Blatt bald nach Zerschneiden welkt und endlich ganz zugrunde geht.

#### 5. *Ischaemum muticum*.

Wahrscheinlich ist diese Pflanze eine der widerstandsfähigsten Gräser gegen Trockenheit auf dem Dünenfelde. Wie man aus ihrer Struktur leicht vermutet, ertragen ihre halmartigen Rhizome eine starke Verdunstung. Im Herbst legte ich ein 10 cm. langes Stück mit einem Knoten im Freien auf den Sand. Schon nach einem Monat bildete sich ein ausgewachsener Laubspross. Diese

Tatsache zeigt, dass dieses Gras wenig Schaden erleidet, wenn es auch ganz auf dem Sande ausgesetzt wird, doch befindet es sich im Freien durch seine befestigenden Wurzeln nur selten in solchem Zustande.

#### 6. *Calystegia Saldanella*.

Da die *Calystegia*-Rhizome eher in seichten Schichten fort-kriechen, werden sie oft ausgegraben. In solchem Falle verlaufen sie leicht an der exponierten Stelle und werden in zwei oder mehr Teile getrennt.

Ihre anderen Eigenschaften sind denjenigen der *Lactuca repens* ähnlich.

#### 7. *Phellopterus littoralis*.

Diese bei Sandüberstäubung so widerstandsfähige Pflanze kann durch Ausgraben nicht weiter leben. Dass sie viele Sprossanlagen am Wurzelstock hat und sich dem Bedürfnis entsprechend entwickeln kann, ist schon erwähnt worden. Diese Eigenschaft ist auch im Falle des Ausgrabens von Vorteil, indem anstatt der oberen die untere noch im Sande bleibende Sprossanlage emporwächst. Wenn jedoch die Pflanze so tief ausgegraben ist, dass alle Ruhesprossen auf dem Sandboden ausgesetzt sind, dann kann sie nicht mehr neue Sprossen austreiben. Solche frei gelegten *Phellopterus*-Pflanzen sehen wir oft auf den Ota Dünen. Im Falle einer vollkommenen Freilegung entwickelt sich aber der unterste Ruhespross doch noch, und vermag sein Leben noch ziemlich lange spärlich zu erhalten, aber allmählich verdunstet und stirbt die Pflanze am Ende ab. Fig. 14 (Taf. II) zeigt solche ausgegrabenen, und dann einen neuen Spross austreibenden *Phellopterus*-Wurzelstöcke. Auf den Vordünen sehen wir immer die durch Einsturz des Sandhügels ausgesetzten *Phellopterus*-Wurzelstöcke, die endlich einen vertrockneten Zustand annehmen.

### Zusammenfassung.

1. Die Dünenpflanzen haben verhältnissmässig schwache Widerstandsfähigkeit gegen Freilegung, besonders ist es der Fall bei den jungen Rhizomen von *Carex macrocephala* und bei den Wurzelstöcken von *Phellopterus littoralis*.

2. Die Hauptursache des Absterbens der Dünenpflanzen ist nicht auf die Sandüberstäubung, sondern auf den Wasserverlust infolge der Entsandung durch Winde oder Hochwasser zurückzuführen.

3. Wenn ein Stück einiger Dünenpflanzen im heissen Sommer durch Zerschneiden des Rhizoms von der Mutterpflanze getrennt wird, so geht es, obgleich seine Wurzeln unversehrt sind, doch sofort oder allmählich zugrunde.

Diese Tatsache zeigt, dass das im allgemeinen als Befestigungs- oder Vermehrungsorgan betrachtete Rhizom auch für die Wasserspeicherung eine wichtige Rolle spielt.

### VIII. Wassergehalt und Wasserverdunstung der unterirdischen Organe von Dünenpflanzen.

Wie oben mitgeteilt wurde, können Dünenpflanzen infolge des Wasserverlustes seitens der unterirdischen Organe das Ausgraben kaum ertragen; denn es ist bekannt, dass der Wassergehalt der Pflanzen in Bezug auf ihre Widerstandsfähigkeit gegen extreme Temperatur die grösste Rolle spielt. Man muss deshalb insbesondere bei Forschung über die Eigenschaften der Dünenpflanzen die Beziehungen der unterirdischen Organe zur Austrocknung oder Verdunstung der Pflanzen in Betracht ziehen.

Meines Wissens, liegen etwaige Angaben nicht vor, welche das



unterirdische Organ der Dünenpflanzen als das wichtigste für die Widerstandsfähigkeit gegen Trockenheit erwiesen hätte.<sup>1)</sup> Die Ursache dieser Widerstandsfähigkeit der Dünenpflanzen wurde bisher ganz und gar auf den besonderen Bau der oberirdischen Organe zurückgeführt. Viele Dünenpflanzen können aber, wie ich schon in der Abteilung I erörterte, ohne besondere Schutzvorrichtung gegen Transpiration wohl im heissen, eingetrockneten Zustande gedeihen.

Um den Einfluss der Bodenfeuchtigkeit auf das Welken der Pflanzen zu sehen, pflanzte ich zweijährige *Phellopterus littoralis* und Rhizomstücke von *Lactuca repens*, die ich vorher im Sande eingegraben hatte, in Glassröhren und Schalen ein. Diese waren mit ausgetrocknetem Quarzsand gefüllt, dessen Gewicht vorher ermittelt worden war. Die beiden Pflanzen wurden zwei Wochen lang mit genügend Wasser versehen und dann im Laboratorium aufgestellt. Ich wartete auf die Zeit, bis der Sand infolge Wasserverdunstung wieder das ursprüngliche Gewicht erreicht hatte. Erst einige Wochen später fingen die Blätter zu welken an. Beim Ausgraben fand ich, dass das Rhizom schon ganz vertrocknet war.

Aus diesen und den vorher geschilderten Versuchen<sup>2)</sup>, die ich in den Dünen mit zerschnittenen Stücken anstellte, kann man ersehen, dass die Widerstandsfähigkeit der Dünenpflanzen gegen Austrocknung wenigstens teilweise auf ihre unterirdischen Organe zurückzuführen ist.

1) Es ist eine bekannte Tatsache, dass das Rhizom im allgemeinen als Speicherorgan für die Baustoffe dient, und zwar sehen wir z. B. bei dem Rhizom von *Carex macrocephala*, viel Stärke besonders auf dem äusseren Teile rings um die Epidermis und um das Gefässbündel. Aber es ist nicht richtig, dieses Organ ganz und gar als Speichersystem für Nährstoffe zu betrachten, insbesondere bei fortwachsenden Rhizomen, wie wir es hier haben. Und natürlich erwiesen viele Forscher solche Rhizome als Befestigungsorgan oder Fortpflanzungsorgan, aber niemand, meines Wissens, hat sie bisher als Wasserspeicherungsorgan gegen Austrocknung erwiesen.

2) Siehe S. 43-45.



Folglich ist es nötig, den Wassergehalt der unterirdischen Organe zu erforschen.

#### A. Wassergehalt der unterirdischen Organe.

Die frisch gesammelten Materialien wurden zuerst gewogen und dann im Trockenschranke ausgetrocknet, bis das konstante Gewicht erlangt war.

Der Wassergehalt der verschiedenen Organe ist in Tabelle V angegeben.

TABELLE V.

Wassergehalt der unterirdischen Organe (I).

Namen d. Pflanzen	Organ	Bemerkung	Frisch- gewicht in g.	Trocken- gewicht in g.	Wasserge- halt in % d. frischen Substanz
1. <i>Carex macrocephala</i>	Rhizom (junges)	34 cm. lang von d. Spitze	7.14	0.79	89.0
2. "	"	37 cm. lang Unterteil von Nr. 1	4.45	0.86	80.7
3. "	"	3 Spitze-Stücke von je 34 cm. Länge	21.71	2.63	87.9
4. <i>Calyptegia Soldanella</i>	Rhizom	40 cm. lang	5.80	1.09	81.2
5. <i>Lactuca repens</i>	"	viele Stücke mit Spitze	13.63	2.86	79.1
6. "	"	ohne Spitze	7.45	1.63	78.1
7. <i>Wedelia prostrata</i>	Ausläufer	ohne Blätter	21.71	4.89	80.2
8. <i>Ischamum anthephoroides</i>	Wurzel	viele alten Wurzeln	5.53	1.15	79.2
9. <i>Calyptegia Soldanella</i>	Blätter	20 Blätter von mehr als 20 mm. Breite	10.73	1.44	86.6
10. <i>Lactuca repens</i>	"	30 Stücke ausgewachsen	8.94	1.20	86.6
11. <i>Wedelia prostrata</i>	"	50 Stücke von mehr als 20 mm. Breite	12.68	1.41	88.9

Versuchszeit: am 19. November 1915.

Material: aus Kugenuma Stranddünen.

Es ist bemerkenswert, dass die Wassermenge des Rhizoms von *Carex macrocephala*, wie erwartet, an der Spitze am grössten ist,

und dass die Wurzeln von *Ischaemum anthephoroides* viel mehr Wasser enthalten, als wir vermuten. Dass das *Carex*-Rhizom bei Aussetzung in freier Luft leicht zugrunde geht, ist aus seinem grossen Wassergehalt zu ersehen.

TABELLE VI.

Wassergehalt der unterirdischen Organe (II).

Namen der Pflanzen	Organ	Bemerkung	Frischgewicht in g.	Trockengewicht in g.	Wassergehalt in % d. frischen Substanz
1. <i>Phellopterus littoralis</i>	Wurzelstock	ohne Blätter	33	8.50	74.2
2. „	„	„	25	7.10	71.6
3. <i>Calystegia Soldanella</i>	Rhizom	viele Stücke mit einigen Blättern	15	2.94	80.4
4. <i>Carex macrocephala</i>	„	Spitze ohne Blätter	28	3.50	87.5
5. <i>Lactuca repens</i>	„	viele Stücke mit vielen Blättern	18.4	2.65	85.6

Versuchszeit: am 24. März.

Material: aus Kugenuma Stranddünen.

TABELLE VII.

Wassergehalt der unterirdischen Organe (III).

Namen der Pflanzen	Organ	Bemerkung	Frischgewicht in g.	Trockengewicht in g.	Wassergehalt in % d. frischen Substanz
1. <i>Carex macrocephala</i>	Rhizom	mit Ästen	6.62	0.81	87.8
2. <i>Calystegia Soldanella</i>	„	mit Blättern	8.25	0.99	81.2
3. „	„	„	17.2	1.92	88.8
4. <i>Lactuca repens</i>	„	„	4.72	0.79	83.3
5. „	„	„	4.22	0.67	84.1
6. <i>Ischaemum anthephoroides</i>	neue Knospe	viele 3-5 cm. lang	5.68	0.47	91.7
7. <i>Carex macrocephala</i>	Blatt	ohne Stamm	12.85	2.46	80.9

8. <i>Carex pumila</i>	Blatt	ohne Stamm	3.25	0.68	79.1
9. „	„	„	4.67	0.98	79.0
10. <i>Ischaemum muticum</i>	Blattspross	einschliesslich Halm	1.31	0.42	68.0
11. <i>Lathyrus maritimus</i>	Blatt	mit Ästen	2.07	0.33	88.9
12. „	„	„	5.16	0.76	85.3
13. <i>Lippia nodiflora</i>	„	„	7.00	0.66	90.6
14. „	„	„	10.05	0.94	90.6
15. <i>Calidum japonicum</i>	„	mit Blattstiel	12.75	1.64	85.0
16. <i>Sagina Linari</i> v. <i>maxima</i>	ausgewachsene Pflanze		8.50	1.55	81.8

Versuchszeit: am 20. April.

Material: aus Kugenuma Stranddünen.

Aus den oben stehenden drei Tabellen ist der durchschnittliche Wassergehalt des Rhizoms der wichtigen Dünenpflanzen wie folgt: <sup>1)</sup>

TABELLE VIII.

Durchschnittlicher Wassergehalt der unterirdischen Organe.

Namen der Pflanzen	Organ	Wassergehalt in % d. frischen Substanz	Nr. d. Tab.	Name	Organ	Wassergehalt in % d. frischen Substanz	Nr. d. Tab.
<i>Phleopteris littoralis</i>	Wurzelstock	73.1	(VII) 1 & 2	<i>Ischaemum antheophoroides</i>	Wurzel	79.2	(V) 8
<i>Calystegia Soldanella</i>	Rhizom	80.6	(V) 4 (VII) 3	<i>Carex pumila</i>	Blatt	79.0	(VII) 8 & 9
<i>Lactuca repens</i>	„	78.8	(V) 5 & 6	<i>Calystegia &amp; Lactuca</i>	„	86.6	(V) 9 & 10
<i>Carex macrocephala</i>	Rhizom (junges)	87.4	(V) 1, 2, 3 (VI) 4 (VII) 1	<i>Lippia nodiflora</i>	„	90.6	(VII) 13 & 14
<i>Ischaemum muticum</i>	Laubspross	68.0	(VII) 10				

Wenn wir die unterirdischen Organe zum Vergleiche heranziehen, so erkennen wir, dass das Rhizom von *Carex macrocephala* besonders viel Wasser enthält, und dass bei den anderen die

1) Zum Vergleich ist der Wassergehalt der anderen Organe auch hier beigelegt.

Wassermenge geringer ist, als bei den gewöhnlichen Blättern (ca. 85%), jedoch ist der Wassergehalt der unterirdischen Organe von Dünenpflanzen noch verhältnismässig reichlich. In Bezug auf die Blätter ist es bemerkenswert, dass der Wassergehalt von Halophyten (z. B. *Lippia nodiflora* und *Wedelia prostrata* haben 90.6% bzw. 88.9%) viel grösser ist, als derjenige der Psammophyten (z. B. *Lactuca repens* und *Calystegia Soldanella* zeigen beide 86.6%). Auch bei *Carex macrocephala* und *Ischaemum muticum* ist der Wassergehalt weit geringer (79% bzw. 80.9%).

#### B. Wasserverdunstung der Dünenpflanzen.

Neuerdings hat KAMERLING eingehende Untersuchungen über Wasserbilanz verschiedener tropischer Pflanzen ausgeführt und darauf hingewiesen, dass die einfache Verdunstungsmethode für das Urteil über die Transpirationsgrösse und Transpirationsregulierung die einfachste und zweckmässigste sei.<sup>1)</sup>

Die Untersuchung über Verdunstung des Rhizoms ist wichtig für die Bestimmung seiner Wasserbilanz, und auch wegen seiner Widerstandsfähigkeit gegen Trockenheit von grossem Interesse. Ich stellte somit einige Versuche über die Verdunstung von wichtigen Dünenpflanzen an. Zuerst legte ich die frisch geernteten Versuchsmaterialien (ausser dem Rhizom wurden auch viele andere Organe zum Versuche benützt) auf den Laboratoriumstisch, der direkter Sonne nicht ausgesetzt war.

Die Resultate der periodischen Wägung waren die folgenden:

#### TABELLE IX.

##### Wasserverdunstung der unterirdischen Organe (I).

1) KAMERLING, Z.: 1914 l. c. S. 434.

Namen der Pflanzen	Datum der Wägungen	Anzahl der Tage seit dem Anfang des Versuchs	Gewicht der Versuchs- pflanze in g.	Gewichtabnahme seit der vorigen Wägung			Totale Verdun- stung seit dem Anfang des Versuchs in %
				total in g.	durch- schnittlich pro. Tag in g.	durch- schnittlich pro. Tag in % des ursprüng- lich. Gew.	
<i>Lactuca repens</i>	24. III 1916	—	16.70	—	—	—	—
	P.M. 5	3	12.35	4.35	1.45	8.8	26.0
	31 „	7	8.16	4.15	1.05	6.0	51.1
<i>Calystegia Soldanella</i>	24 „	—	10.70	—	—	—	—
	27 „	3	4.90	5.80	1.93	18.0	54.2
	31 „	7	3.28	1.62	0.41	3.8	69.3
<i>Phellopterus littoralis</i>	24 „	—	73.20	—	—	—	—
	27 „	3	51.9	21.3	7.1	9.7	29.0
	31 „	7	31.2	20.7	5.2	7.1	56.5
	12 IV	19	20.1	11.1	0.93	1.3	72.5

Wir sehen aus Tab. IX, dass der Grad der Verdunstung ein ganz verschiedener ist, und dass das Rhizom von *Lactuca repens* besonders wenig verdunstet.

Weitere Versuche werden im folgenden gezeigt:

TABELLE X.

## Wasserverdunstung der unterirdischen Organe (II).

Namen der Pflanzen	Anzahl der Tage seit dem Anfang des Versuchs	Gewicht der Versuchs- pflanze in g.	Gewichtabnahme seit der vorigen Wägung			Totale Verdunstung seit dem Anfang des Versuchs in %	
			total in g.	durch- schnittlich pro. Tag in g.	durch- schnittlich pro. Tag in % des ursprüng- lich. Gew.	des Frischgew.	des Wassergew.
1. <i>Carex macrocephala</i>	1	6.62	—	—	—	—	(Trockengew.)
	3	4.92	1.70	1.70	25.7	25.7	0.81
	6	3.92	1.00	0.50	7.6	40.8	24.3
Rhizom	6	3.07	0.85	0.28	4.2	53.6	46.5
	16	1.45	1.62	0.16	2.4	78.1	61.1
							80.0
2. <i>Calystegia Soldanella</i>	1	17.20	—	—	—	—	( „ )
	3	9.12	8.08	8.03	47.0	47.0	1.52
	6	4.10	5.02	2.51	14.6	76.2	59.7
Rhizom	6	2.71	1.31	0.46	2.7	81.3	85.7
	16	2.31	0.40	0.04	0.2	86.6	84.3
							90.9
3. <i>Calystegia Soldanella</i>	1	8.25	—	—	—	—	( „ )
Blatt	3	5.11	3.11	3.11	37.7	37.7	0.99
	6	2.28	2.86	1.43	17.3	72.4	42.8
mit Blattstiel	6	1.48	0.81	0.27	3.3	82.3	82.2
und Asten	16	1.14	0.34	0.03	0.4	86.4	93.3
							97.9

4. <i>Lactuca repens</i>		8.94	—	—	—	—	(Trockengew.)
Rhizom	1	6.90	2.04	2.04	22.8	22.8	1.31
	3	4.79	2.11	1.06	11.9	46.4	26.7
	6	3.29	1.50	0.59	5.6	63.2	54.4
	16	1.73	1.56	0.16	1.9	80.7	74.1
							96.1
5. <i>Ischaemum anthephoroides</i>		5.68	—	—	—	—	( " 0.47 )
	1	3.48	2.20	2.20	38.7	28.7	42.2
	3	2.18	1.39	0.65	11.4	61.6	67.2
neuer Spross	6	1.57	0.61	0.20	3.5	74.1	78.9
	16	0.80	0.77	0.08	1.4	85.9	94.2
6. <i>Carex macrocephala</i>		12.85	—	—	—	—	( " 2.46 )
	1	7.85	5.00	5.00	38.9	38.9	48.1
	3	6.08	1.77	0.89	6.9	51.9	65.2
Blätter	6	4.90	1.18	0.37	2.9	61.8	76.5
	16	3.70	1.20	0.12	0.9	77.3	88.1
7. <i>Carex pumila</i>		7.92	—	—	—	—	( " 1.65 )
	1	4.07	3.85	3.85	48.6	48.6	61.4
Blätter	3	2.90	1.17	0.59	7.5	63.1	80.1
	6	2.51	0.38	0.13	1.6	68.2	86.1
	16	2.02	0.49	0.05	0.6	74.4	93.9
8. <i>Ischaemum medium</i>		1.31	—	—	—	—	( " 0.42 )
	1	0.75	0.56	0.56	42.8	42.8	62.9
	3	0.57	0.21	0.11	8.1	51.2	86.6
Laubspross	6	0.52	0.02	0.07	0.5	51.7	88.8
	16	0.46	0.16	0.06	0.4	52.0	95.6
9. <i>Lathyrus maritimus</i>		7.23	—	—	—	—	( " 1.09 )
	1	2.53	4.70	4.70	65.0	65.0	76.5
Blätter	3	1.47	1.06	0.53	73.3	79.7	93.8
mit Ästen	6	1.31	0.16	0.05	6.9	81.9	96.4
	16	1.25	0.06	0.06	0.8	82.7	97.1
10. <i>Lippia nodiflora</i> v.		17.05	—	—	—	—	( " 1.60 )
	1	9.62	7.43	7.13	43.6	43.6	62.3
Blätter	3	3.18	6.44	3.22	18.9	81.4	89.7
mit Ästen	6	2.47	0.71	0.37	1.6	85.5	91.4
	15	1.99	0.18	0.05	0.3	88.3	97.5

Versuch vom 29 IV bis zum 6 V.

Vgl. Tabelle VII auf S. 50.

N.B.—Bei diesen Pflanzen verfuhr sich in derselben Weise, wie bei dem vorigen Versuche; nämlich die frisch gesammelten Materialien wurden an einer schattigen Stelle auf dem Arbeitstisch im Laboratorium ausgelegt.

Aus dieser Tabelle erschen wir, dass der Verdunstungsvorgang besonders im Anfang deutlich sichtbar ist, und dass schon nach einer Woche einige der Versuchsmaterialien ganz vertrocknet und abgestorben sind. Die erste Erscheinung ist, dass die Intensität der Verdunstung in den ersten 24 Stunden steigt, um nachher beträchtlich abzunehmen; und zwar bei den Mustern 2, 6, 7, 8, 9 und 10 stellt die Verdunstungsmenge in dieser Zeit fast den



ganzen Wassergehalt oder mehr als die Hälfte desselben vor, aber bei den übrigen Mustern geht die Wasserverdunstung ganz allmählich vor sich.

Obgleich der Wasserverlust am Anfang sehr stark ist, nimmt er doch bald bedeutend ab, z. B. beträgt er bei dem *Lactuca*-Rhizom in den ersten 24 Stunden 22.8%, aber nach drei Tagen in derselben Frist, d. h. innerhalb 24 Stunden, nur 5.8% des ursprünglichen Gewichts. Noch viel beträchtlicher ist der Wasserverlust bei Blättern von anderen Pflanzen am ersten Tage, z. B. bei *Lathylus maritimus* ist er 65%, während er am dritten Tage nur ca. 0.7% (pro 24 Std.) des ursprünglichen Gewichts beträgt.

Aus den obigen Versuchen ist es auch ersichtlich, dass die Verdunstung der unterirdischen Organe im Vergleich mit den Blättern, sogar im jungen und frischen Stadium, verhältnismässig gering ist.<sup>1)</sup> Diese Tatsache ist ein wichtiger Punkt für die Erörterung der Eigenschaften von Dünenpflanzen, besonders der Rhizompflanzen, weil sie wegen dieser Eigenschaft bei der Freilegung bisweilen sehr lang standhalten können, bis sie wieder von Sande überschüttet werden.

### Zusammenfassung.

1. Obwohl bei den wichtigen Dünenpflanzen der Wassergehalt des Rhizoms geringer ist, als derjenige der Blätter, so besitzt ersteres doch noch so viel Wasser wie 80% seines Frischgewichtes.

2. Der Wassergehalt ist besonders reichlich an der Spitze des Rhizoms und an der Wurzel, und diese wichtigen Teile trocknen bei der Freilegung (Ausgraben) leicht aus.

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1) *Calyptegia Soldanella* macht eine Ausnahme, insofern die Verdunstung des Rhizoms stärker ist als bei den Blättern. Durch diese Eigenschaft wird das Rhizom von *Calyptegia Soldanella* beim Ausgraben leicht zerschnitten. (Siehe S. 46).

3. Der Verdunstungsgrad ist aber bei den unterirdischen Organen geringer als bei den Blättern. Diese Tatsache ist von einer Bedeutung für Dünenpflanzen, weil sie infolgedessen bei der Freilegung die starke Verdunstung eine Zeit lang ertragen können.

### IX. Regenerationsfähigkeit der Dünenpflanzen.

Unter dem Namen Regeneration fassen wir mit Jost<sup>1)</sup> zwei Formen der Restitution zusammen: Neubildung von Organen in der Nähe der Wunde und Neuentfaltung der der Wunde nächststehenden, bereits vorher vorhandenen Organanlage.

In vorliegender Arbeit stellte ich Versuche über die Regenerationsfähigkeit der Dünenpflanzen als Komplement ihrer Vermehrungsfähigkeit an. Im ersten Teil haben wir zuerst die Versuche im Naturzustande. Hier sind auch die Ergebnisse der Versuche berücksichtigt, die in dem Sandfelde im Garten unseres Institutes und auch in den Kästen im Gewächshause angestellt wurden. Dagegen beschäftigte ich mich im Laboratorium, wie wir aus dem zweiten Teile sehen, mehr mit Versuchen in Bezug auf Neubildung, als mit solchen betreffs Neuentfaltung von Organen.

#### A. Versuche im Naturzustande.

Nachstehend berichte ich über die Ergebnisse der Versuche, die hauptsächlich in den Ōta Dünen angestellt wurden.<sup>2)</sup>

Die Versuchsmethode im Freien ist folgende: Ein Teil der wichtigen Dünenpflanzenkörperchen wurde am 14. August 1915

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1) JOST, L.: Vorlesungen über Pflanzenphysiologie. 3 Aufl. 1913. S. 442.

2) Einige schon in Abteilung VI beschriebene Ergebnisse wurden hier kurz oder nicht wiederholt.

abgeschnitten, worauf die Resultate im Dezember 1915 und im April 1916 geprüft wurden.

1. *Carex macrocephala*.

Versuche No. 35 und No. 37. Ich schnitt einen Teil des Rhizoms nebst Laubsprossen von der Mutterpflanze ab, die, wie bereits erwähnt, ohne Regenerationsfähigkeit bald zugrunde gingen, obgleich sie nicht verletzt waren.

Viele mit kleinen Sprossen versehene Stammknollen waren auch im Sommer in genügend befeuchteter Tiefe auf einem Dünen-gipfel eingegraben, wo dieses Gras gut wächst, aber selbst im Frühling trieben diese Stammknollen keine Laubsprossen aus, obwohl einige unterirdische Sprossen noch Lebensfähigkeit hatten.

2. *Lactuca repens*.

Versuch No. 5. Drei 5 cm. lange Rhizomstücke wurden an der Spitze abgeschnitten, nämlich: (A) ein Stück mit drei noch nicht ausgewachsenen Internodien und ihren im Sande liegenden Blattanlagen, (B) und (C) je ein Stück mit Knoten und entfaltetem Blatt.

Das Ergebnis im Dezember war folgendes:—Das (A) Stück erreichte 87 cm. Länge ohne Seitensprossen und die (B) und (C) Stücke trieben 18 cm. bzw. 13 cm. lange Seitentriebe aus der Blattachsel aus. Diese beiden wuchsen zuerst aufwärts bis ca. 2 cm. Höhe und dann wieder in horizontaler Richtung. In diesem Falle zeigte sich keine Wurzel in der Nähe der abgeschnittenen Wunde.<sup>1)</sup>

Versch No. 31. Ein Rhizom wurde von der Spitze in drei Teile zerschnitten: Das erste Stück (A) 10 cm. lang mit schon sichtbar gewordenen Laubblättern, das zweite Stück (B) auch 10 cm.

---

1) Vergl. die Versuche im Laboratorium.

lang mit drei Knoten und drei aus demselben entsprungenen Blättern und das letzte (C) bestehend aus dem Rhizomrest mit vielen Knoten und Blättern. Bis zum Dezember verlängerte sich (A) um 55 cm., während bei (B) sich ein 8 cm. langer Trieb auf dem apikalen Knoten einstellte. (C) trieb 78 cm. und 67 cm. lange Seitentriebe aus dem apikalen bzw. den folgenden Knoten aus.

Bei diesem Versuche möchte ich zwei Punkte in Betracht ziehen.

a. Wenn der Vegetationspunkt eines Stückes verletzt wird, entwickelt sich sofort eine ruhende Sprossanlage auf dem apikalen Knoten.

b. Die Länge des neu ausgetriebenen Sprosses ist von dem Triebe des Mutterstückes abhängig.

### 3. *Ischaemum muticum*.

Versuch No. 23. Auf einem langen unterirdischen, halmartigen Rhizom wurden neun Stücke, jedes mit einem einzigen Knoten, von der Spitze bis zum Grunde, von einander getrennt. Das Resultat lässt sich wie folgt zusammenfassen:

Jedes Stück, mit Ausnahme des ältesten, hat wagerecht kriechende Triebe ausgesprosst, und letztere haben auch schon Laubsprossen und gleichfalls einige Wurzeln auf dem ersten Knoten getrieben. Diese Versuche zeigen, dass selbst ein Stück dieser Pflanze kräftige Regenerationsfähigkeit hat.

### 4. *Ischaemum anthephoroides*.

Über diese Pflanze habe ich schon vorher beschrieben und füge nachstehend ein Beispiel hinzu:

Versuch No. 19. Während der mit nur einer einzigen Wurzel isolierte Stengel keine Wurzel hervorgebracht hat, hat der mit zwei Wurzeln versehene Stengel eine Wurzel von 51 cm. Länge zwischen den beiden alten Wurzeln und noch zwei weitere, von

16 cm. bzw. 15 cm. Länge, auf dem unteren Knoten getrieben.

Als Ergebnis der isolierten Versuche kennen wir die Tatsache, dass, wenn ein Teil dieses Grases verletzt wird, die Wurzelbildung in Tätigkeit tritt, wenn auch die oberirdischen Laubsprossen allmählich zugrunde gehen.

#### 5. *Phellopterus littoralis*.

Diese Pflanze hat, wie ich schon erwähnte, eine für die Regeneration sehr günstige Eigenschaft, weil sie mit vielen Ruhsprossen auf dem Wurzelstock versehen ist.

Versuch No. 11. Ein unterirdischer Teil wurde in drei Stücke

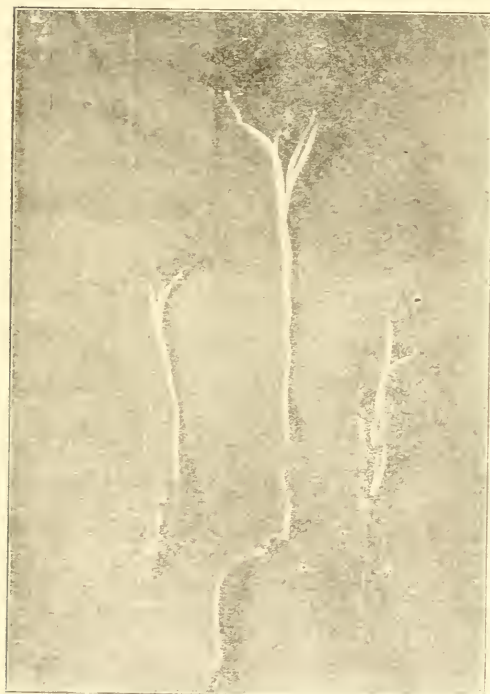


Fig. 6.—*Phellopterus littoralis*.

Drei aus einem Wurzelstock im Winter von einander getrennte Stücke. Von dem Stücke rechts alle Knospen mit Ausnahme der untersten entfernt.

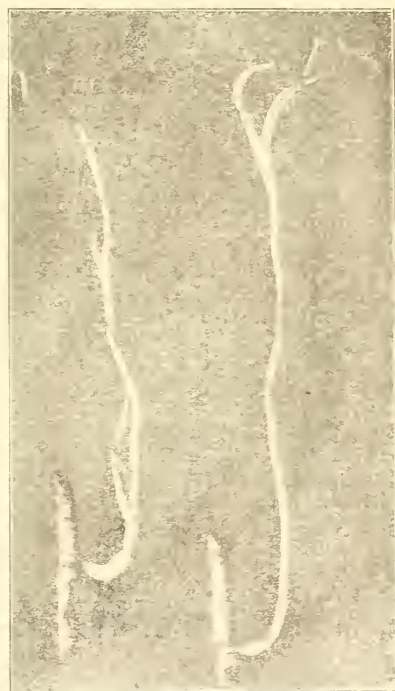


Fig. 7.—Dieselbe Pflanze.

Zwei 10 cm. lange Stücke, welche im Winter umgekehrt auf Dünen eingegraben wurden, trieben junge Sprossen (im April aufgenommen); von der rechten waren die basalen Knospen entfernt worden.



getrennt: (A) von 6 cm. Länge, (B) von 7 cm. und (C) Rest ohne Sprossanlage. Bis zum Dezember entwickelten sich bei den Stücken (A) und (B) die obersten Sprossanlagen, aber das letztere brachte keinen Laubspross hervor, obwohl es volle Lebensfähigkeit hatte.

Versuch No. 8. Ein Wurzelstock wurde in Tiefe von 5 cm. in zwei Teile getrennt.

Viele Wurzeln kamen an der Wunde des oberen Stücks hervor, aber an dem unteren Stück entfaltetete sich nur eine der Wunde am nächsten stehende Ruhesprossanlage, welche die Oberfläche schon im Dezember erreichte.

Versuch No. 4. Im Winter schnitt ich einen Wurzelstock in Tiefe von 8, 13 und 18 cm. ab und lies diese 3 Teile in diesem Zustande sich entwickeln. Nur von dem obersten Teile wurden die Laubblätter und alle Knospen, ausser der untersten, entfernt. Das Resultat in der Frühlingszeit, wie Fig. 6 zeigt, ist folgendes: In diesem Falle entwickelte sich die am obersten liegende Knospe, falls eine solche vorhanden war, und gleichfalls brachen viele Wurzeln an der geschnittenen Stelle hervor.

Versuch No. 6. In derselben Weise, wie beim vorigen Versuche, wurden zwei Stücke, jedoch im umgekehrten Zustande in den Sand gesteckt (Fig. 7). Trotzdem entfaltetete sich immer die apikale Knospe, wenn dieselbe unverletzt geblieben war.

Die Resultate im Sandfelde im Garten waren ganz ähnlich, wie beim vorigen Versuche im Naturzustande, nur ist es beachtenswert, dass die Stücke hier mit vielen Wurzeln versehen waren, wahrscheinlich wegen der genügenden Feuchtigkeit im Sande. Ausserdem ist es zu bemerken, dass das Rhizom-Stück bei verschiedenen Pflanzen (*Carex macrocephala*, *C. pumila*, *Ischaemum muticum*, *Lactuca repens*, *Calystegia Soldanella*, *Wedelia prostrata* und *Phellopterus littoralis*), wenn ihm ein Knoten bzw. eine



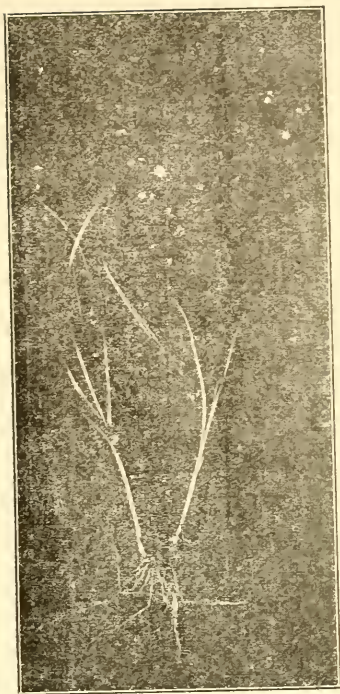


Fig. 8.

*Carex macrocephala.*

Ein 2 cm. langes Stück mit einem Knoten wurde im Sommer auf Quarzsand bei genügender Feuchtigkeit angelegt. Im Frühling entwickelten sich neue Sprossen.

Sprossanlage fehlt, keinerlei Neubildung von Organen zeigt, obwohl es im Sande viele Monate (vom Herbst bis zum Sommer) am Leben geblieben ist<sup>1)</sup>. Dagegen sind die mit Sprossanlage versehenen Stücke beinahe alle wohl gediehen, indem sie Laubsprossen entfalteten. Ein Beispiel von *Carex macrocephala* sehen wir in den Abbildungen 8.

Zum Schlusse möchte ich darauf aufmerksam machen, dass besonders bei den Stücken von *Lactuca repens* und *Lathylus maritimus* Neubildung von Wurzeln in der Nähe der abgeschnittenen basalen Wunde, jedoch nicht an der apikalen Wunde stattfindet, und dass im allgemeinen die obere Partie (apikale) allmählich bis zum Knoten in Fäulnis übergeht.

Aus obigen Versuchen erleuchtet es, dass bei diesem kriechenden Rhizomstück die Polarität schon bestimmt ist.

## B. Versuche im Laboratorium.

Folgende Versuche stellte ich mit *Lactuca repens* im Laboratorium an:

Rhizomstücke verschiedener Länge (5–20 mm.) wurden aufrecht in eine mit sterilisiertem, befeuchtetem Quarzsande gefüllte Schale gesetzt, die mit einer Glasglocke überdeckt war.

1) Einige Stücke von *Phellopterus littoralis* waren verfallen.

Nach einem Monate brachten die mit Knoten versehenen Stücke einen Spross, und die meisten auch zwei Wurzeln hervor, während alle Internodienstücke weder Spross noch Wurzel trieben. Somit ist es klar, dass sich nur die mit Knoten versehenen Stücke leicht entwickeln können. Bei einem weiteren Versuche benützte ich daher nur solche Stücke, die mit Knoten versehen waren. Diese in eine Schale gesetzten Stücke wurden an einer hellen, jedoch nicht der Sonne ausgesetzten Stelle, im Gewächshaus aufgestellt.

Das Ergebnis ist in folgender Tabelle zusammengefasst:

TABELLE XI.  
Lebensfähigkeit der Rhizomstücke.

Rhizomstücke Länge in mm.	Anzahl	Zustand	Bemerkung	Resultat
5	13	aufrecht	ohne Knoten	gesund
10	12	„	„	„
10	6	„	halbes Stück ohne Knoten	„
15	3	„	ohne Knoten	„
5	5	umgekehrt	„	„
10	8	„	„	„
15	8	„	„	„
10	1	„	mit Spitze	abgestorben
10	1	aufrecht	„	„
5	2	„	mit Knoten	gesund, beide trieben einige Wurzeln aus
15	1	„	„	gesund, Spross erreichte bis zu 20 mm
10	4	unter Sand liegend	ohne Knoten	abgestorben
Blattstielstücke				
5	3	aufrecht	—	abgestorben
10	8	„	—	„
15	3	„	—	„

Versuch vom 29 X bis zum 18 XI, 1915.

Wie man aus dieser Tabelle leicht ersieht, erhielten sich die Rhizomstücke, mit Ausnahme der Spitzenstücke, sehr wohl, während alle Blattstiele abgestorben sind.

Die mit Knoten versehenen Stücke brachten Wurzeln oder Sprossen hervor, und strebten danach, sich zu entwickeln. Was das Absterben der unter Wasser liegenden Stücke anbetrifft, so möchte ich dasselbe auf den Mangel an Sauerstoff in der Wasserschicht zurückführen, deren Bedeutung schon VÖCHTING bewiesen hat.<sup>1)</sup>

Ferner stellte ich einen Versuch über das Verhältnis zwischen der Spross- und Wurzelbildung unter Berücksichtigung der Polarität an. Zu diesem Zwecke steckte ich viele mit Knoten versehene Stücke gerade oder umgekehrt in den Sand, und nach einem Monat sowie nach drei Monaten, wurde die Anzahl der entwickelten Sprossen und Wurzeln festgestellt, wie aus der folgenden Tabelle ersichtlich ist :

TABELLE XII.  
Regenerationsfähigkeit der Rhizomstücke.

			Nach einem Monate						Nach drei Monaten						
Länge in mm.	Anzahl	Zustand	Anzahl der		Anzahl d. gesunden Stücke mit				Anzahl der		Anzahl d. gesunden Stücke mit				
			abgestorb. Stücke	gesund. Stücke	W & S	2W & S	W	S	abgestorb. Stücke	gesund. Stücke	W & S	2W & S	3W & S	W	S
5	14	aufrecht	0	14	6	2	1	0	1	13	4	5	0	0	1
10	12	„	0	12	4	3	0	3	2	10	6	4	0	0	1
15	8	„	0	8	4	3	0	0	0	8	2	3	1	1	0
5	8	umge- kehrt	2	6	0	0	2	0	8	0	0	0	0	0	0
10	14	„	2	12	5	3	0	0	6	8	2	3	2	0	0
15	8	„	0	8	3	0	0	2	3	5	1	1	2	1	0

N.B.—W bedeutet eine Wurzel, S einen Spross und 2 W & S zwei Wurzeln und einen Spross etc. Versuche vom 22 II bis zum 22 V, 1916.

1) VÖCHTING, H.: Über Organbildung im Pflanzenreich. Bonn. 1873.

Durch diesen Versuch ist es erwiesen, dass bei den aufrecht gesetzten Stücken eine geringere Anzahl zugrunde geht, als bei den umgekehrt gesetzten Stücken. Bei den ersteren sind sogar nach drei Monaten noch 90% der Versuchsstücke gesund, während bei den letzteren die gesunden Stücke nach einem Monate auf 87% und nach drei Monaten schon auf nur 43% zurückgehen. Wir können somit verstehen, dass das horizontal kriechende Rhizom selbst in umgekehrter Lage ein ungünstiges Verhältnis darstellt. Die aufrechten Stücke verhalten sich ganz anders als die umgekehrten, und zwar die meisten der ersteren brachten neue Organe hervor, d.h. ca. 80% ihrer Versuchsstücke, während bei den letzteren nur 60% ihrer Versuchsstücke Wurzeln oder Sprossen austrieben.

Ich hatte hierbei Gelegenheit, die Beziehung zwischen Wurzel- und Sprossbildung auf dem Stücke zu sehen. Es ist kaum nötig zu sagen, dass zwischen beiden eine bedeutende Korrelationerscheinung zu beobachten ist. Welche von beiden Bildungen zuerst stattfindet, ist jedoch eine Frage. Nach der Tabelle XII ist die Anzahl der nur mit einer Wurzel versehenen und die der nur mit einem Spross versehenen Stücke zufällig gleich. Die Gesamtanzahl der nach drei Monaten aus den 36 Stücken neu hervorgebrachten Wurzeln ist 49, von denen 36 Wurzeln d.h. 74% der ganzen Wurzeln aus den neu ausgetriebenen Sprossen sich bildeten, während die übrigen auf dem Stücke nahe am Knoten ausgetrieben wurden. Die Resultate nach einem Monat zeigen andererseits, dass die Zahl der neu gebildeten Sprossen und Wurzeln 5 resp. 3 ist.

In manchen Fällen entwickeln sich daher zuerst die Sprossanlagen und dann sofort auf deren untersten Knoten ein oder zwei Wurzeln, welche schnell in den Boden hineinwachsen.

### Zusammenfassung.

1. Die Rhizomstücke der *Carex*-Arten entfalten keine Sprossen, wenn sie auch im Sande lange Zeit ihre Lebenskeime behalten, dagegen ist dasselbe bei *Ischaemum anthephoroides* und *I. muticum* der Fall.

2. *Lactuca repens* und *Phellopterus littoralis* haben kräftige Regenerationsfähigkeit. Bei *Phellopterus littoralis* fängt der apikale Spross, ungeachtet der Lage des Stückes im Sande, sich zu entfalten an.

3. Die Polarität bei kriechenden Rhizomstücken ist bestimmt.

4. Bei Regeneration der Rhizomstücke von *Lactuca repens* trieben im allgemeinen zuerst die Sprossen und dann aus letzteren die Wurzeln hervor.

### X. Anhang. Festigkeitmodul der unterirdischen Organe der Dünenpflanzen.

Wie die unterirdischen Organe in lockerem Sandboden bei heftigem Winde ihre oberirdischen Organe erhalten können, ist ein wichtiges Problem für die Dünenforschung.

Ein solcher Festigkeitmechanismus muss natürlich durch Rhizom und Wurzel gemeinsam gebildet werden.

Was die Widerstandsfähigkeit der Pflanzen gegen die Wirkung des Entwurzelns anlangt, so bedarf es des Festigkeitmoduls, d.h. der Maximalbelastung bei dem Zerreißen, und nicht des Tragmoduls. Deshalb stellte ich über die Dehnbarkeit der Fasern keine besonderen Versuche an. Es ist eine selbstverständliche Sache, dass das Festigkeitmodul in trockenem Zustande von geringem Wert ist. Da letzteres vom ökologischen Gesichtspunkte aus



betrachtet, wenig Bedeutung hat, benutzte ich nur frisch geerntete Materialien.

Die Versuche wurden oft wiederholt, und das Material sofort nach dem Zerreißen gemessen.

Die Resultate ergeben sich aus der folgenden Tabelle:

TABELLE XIII.

Festigkeitsmodul der unterirdischen Organe der wichtigsten Dünenpflanzen.

Namen der Pflanzen	Organ	Bemerkungen	Belastung kg.	Durch- mess. des Zentral- zylinders mm.	Flächen- raum des Zentral- zylinders mm <sup>2</sup>	Festigkeit- modul kg/mm <sup>2</sup>
<i>Lactuca repens</i>	Rhizom	Gefäßbündelring verholzt	1.4	2.56	5.038	0.28
<i>Calystegia</i> <i>Soldanella</i>	"	Stereomring und Epidermis verholzt	3.5	3.53	10.101	0.35
<i>Carex</i> <i>macrocephala</i>	"	Zentralzylinder ganz verholzt	13.0	1.70	2.270	5.73
"	Junges Rhizom	"	2.5	1.44	1.628	1.54
"	Wurzel	"	3.4	0.50	0.196	17.35
<i>Ischaemum</i> <i>muticum</i>	"	mit Ausnahme der Mark Zentralzylinder verholzt	1.3	0.57	0.255	5.10
<i>Lathylus</i> <i>maritimus</i>	"	Ein Teil im Zentral- zylinder verholzt	2.2	1.28	1.287	1.71
<i>Ischaemum</i> <i>anthephoroïdes</i>	"	Zentralzylinder ganz verholzt	6.0	0.64	0.322	18.63
<i>Fimbristylis</i> <i>sericea</i>	"	"	0.4	0.26	0.053	7.55

N.B.:—Obige Versuche wurden am 10. Feb. 1916 im Laboratorium ausgeführt.

Es ist nicht richtig, die Zentralzylinder ohne weiteres als mechanisches Gewebe, von welchem die Belastungstätigkeit der Gewebe grösstenteils abhängt, zu betrachten. Zum Vergleich der Stärke der Belastungskraft mit den unterirdischen Organen verschiedener Pflanzen ist es aber zweckmässig, die Zentralzylinder als Einheit der Belastungstätigkeit anzusehen.



Zum Schluss möchte ich über die Belastungstätigkeit einiger Dünenpflanzen kurz berichten :

Wie aus obiger Tabelle ersichtlich ist, ist das Festigkeitsmodul der Wurzel viel grösser als dasjenige des Rhizoms.

Bei *Carex macrocephala* besteht ein ausgeprägter Unterschied des Festigkeitsmoduls zwischen dem jungen Rhizom und dem alten. Ein Rhizom dieses Grasses erträgt eine Belastung von über 13 kg. Weil das Rhizom mit so starker Belastungskraft versehen ist, kann dieses Gras sich über einen solch weiten Raum ausbreiten. Auch sehen wir, wie stark die Belastungskraft seiner Wurzel ist, durch welche dieses Rhizom im lockeren Sande befestigt ist.

Die Wurzeln von *Ischaemum anthephoroides* zeigen eine grössere Belastungstätigkeit, und zwar ihre Faser kann im Milimeterquadrat ein Gewicht von 18.6 kg. halten, was für eine gewöhnliche Wurzel von *Ischaemum anthephoroides* ca. 6 kg. beträgt. Da diese Pflanze mit so vielen solchen Wurzeln (oft 30–60) im Sandboden verwachsen ist, können wir leicht vermuten, wie gross ihre Widerstandsfähigkeit gegen Entwurzelung ist.

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### Inhaltsverzeichnis.

	Seite
I. Einleitung .....	1
II. Allgemeine Eigenschaften der Dünenpflanzen .....	4
III. Geographische Verhältnisse der Ōta Dünen .....	8
A. Edaphische Bedingungen .....	10
B. Klimatische Bedingungen .....	12
IV. Verbreitung der Dünenpflanzen auf den Ōta Dünen .....	17
A. Geographische Verbreitung der Dünenflora .....	18
B. Topographische Verbreitung der Dünenflora .....	20
V. Art und Weise der Vermehrung der Dünenpflanzen .....	25
VI. Widerstandsfähigkeit der Dünenpflanzen gegen Sandüberstäubung .....	36
Anhang. Ruhezeit der Dünenpflanzen .....	42
VII. Widerstandsfähigkeit der Dünenpflanzen gegen Trockenheit ....	43
VIII. Wassergehalt und Wasserverdunstung der unterirdischen Organe von Dünenpflanzen .....	47
A. Wassergehalt der unterirdischen Organe .....	49
B. Wasserverdunstung der Dünenpflanzen .....	52
IX. Regenerationsfähigkeit der Dünenpflanzen .....	56
A. Versuche im Naturzustande .....	56
B. Versuche im Laboratorium .....	61
X. Anhang. Festigkeitsmodul der unterirdischen Organe der Dünenpflanzen .....	65

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Oekologische Studien über Vegetation der Ōta Dünen.

Tafel I.

## Erklärung der Tafel I.

Fig. 1. Walddünen (Kiefern Wald) vom Toné Fluss aus gesehen.

*Pinus Thunbergii* ist angepflanzt; davon links *Juniperus rigida*.

Fig. 2. Sandfeld; befestigt mit *Ischoemum antheophoroides*, *I. muticum*, *Phellopterus littoralis*, und halb mit Sand überschütteten Kiefern. Im Hintergrund *Elwagnus*-Horste zu sehen; rechts am Horizont befindet sich eine Dünenkette.

Fig. 3. Vertieftes Sandfeld.

Nach Hochwasser verwandeln sich die vertieften Stellen in Teiche; vorn *Carex macrocephala*-Formation zu sehen.

Fig. 4. Sandstrand an der Kashimasee.

Wenig erhöhte Vordünen mit *Phellopterus littoralis* und *Wedelia prostrata* Formationen.

Fig. 5. *Juniperus*-Horste im Sandfelde, einige Kiefern angesiedelt; im Hintergrund gürtelartige Dünenkette.

Fig. 6. *Elwagnus*-Horste im Sandfelde; zu bemerken, dass beide Horste je nach ihrem Alter von verschiedener Gestalt sind.



*Yoshii photo.*





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Tafel II.

## Erklärung der Tafel II.

Fig. 7. *Carex pumila*-Formation in vertieftem Dünenfelde.

Im Hintergrunde ein Sandhügel, auf dessen Gipfel *Carex macrocephala* gedeihen.

Fig. 8. *Carex macrocephala*-Formation auf dem Gipfel des Hügels, der auf Fig. 7 in der Entfernung zu sehen ist.

Fig. 9. *Phellopterus littoralis*.

Mit Sand bedeckte Pflanze. Die ruhende Knospe fing sich wegen Sandüberstäubung zu entwickeln an. Spross rechts erreicht noch nicht die Oberfläche (Beide im Winter bei Kugenuma Sandstrand gesammelt).

Fig. 10. *Ischaemum antheophoroides*.

Links drei vom Sommer bis Frühling mit Sand überschüttete Pflanzen; Rechts normaler Zustand im Frühling. Zu bemerken ist, dass bei sandbedeckten Pflanzen neue Laubsprossen, anstatt des unteren Knoten, wo alte Wurzeln getrieben hatten, aus dem 5. oder 6. ten Knoten hervorkommen.

Fig. 11. Mit Sand überschüttete Stücke von *Calystegia Soldanella*.

Im Herbst im Sande im Gewächshause eingegraben und im Winter aufgenommen.

Fig. 12. *Ischaemum antheophoroides*, auf dem Sandfelde durch Wind ausgegrabene Pflanze (aufgenommen im April).

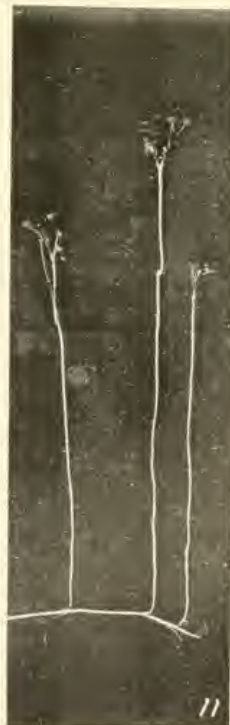
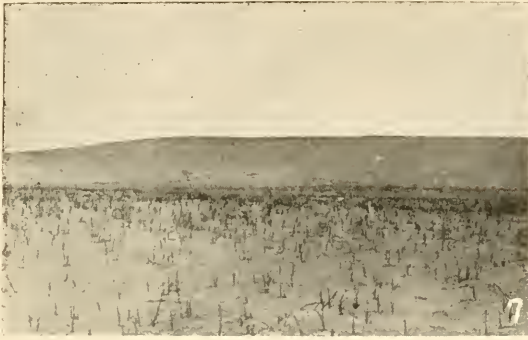
Viele Wurzeln dienen in wagerechter Verbreitung zur Befestigung der Pflanze in lockerem Sandboden.

Fig. 13. Eine durch Wind freigelegte *Carex macrocephala*-Formation.

Rhizom der Luft ausgesetzt. Haben sogar im Frühling fast nie Neubildungskraft von Sprossen. (Aufgenommen im April bei Ōta Dünen) Vergl. Fig. 8.

Fig. 14. *Phellopterus littoralis*, auf vertieftem Sandfelde wachsende Pflanze.

Der Sand war von der Oberfläche weggespült oder fortgeblasen. Infolgedessen vertrocknete der obere Teil der Pflanze allmählich, und die im Sande ruhende Knospe entfaltete sich.



*Yoshii photo.*



## Über die relative Wirksamkeit von Kreuz- und Selbstbefruchtung bei einigen Pflanzen.

Von

Yoshikadzu EMOTO, *Rigakushi*.

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Mit 2 Tafeln und 6 Textfiguren.

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### I. Einleitung.

Es ist wohl bekannt, dass das Androecium einer Blume sich nicht gleichzeitig mit ihrem Gynaecium entwickelt, und dass einige Blumen bei Kreuzung zu leichter Befruchtung hinneigen. KÖLREUTER<sup>1)</sup> führte zum ersten mal ausführliche Untersuchungen über Hybridation bei *Nicotiana*, *Verbascum*, *Dianthus*, *Hibiscus*, *Datura*, *Sida* und *Cucurbita* aus. Er teilte mit, dass bei Kreuzung, ob von der gleichen Varietät derselben Species oder von einer verschiedenen Varietät derselben Species, leichtere Befruchtung erzielt werde, als bei Befruchtung mit dem eigenen Pollen, und dass die aus einer Kreuzung hervorgegangenen Abkömmlinge besser seien, als die selbstbefruchteten, in Bezug auf Wachstum und Fruchtbarkeit. DARWIN<sup>2) 3)</sup> und TSCHERMAK<sup>4)</sup> kamen zum gleichen Schluss wie

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1) KÖLREUTER, J.: Vorläufige Nachricht von einigen das Geschlecht der Pflanzen betreffenden Versuchen und Beobachtungen. 1761-66.

2) DARWIN, CH.: The effects of cross- and self-fertilisation in the vegetable kingdom. 1876.

3) DARWIN, CH.: The different forms of flowers on plants of the same species. 1877.

4) TSCHERMAK, F.: Über den Einfluss der Bestäubung auf die Ausbildung der Fruchthüllen. Ber. d. d. Bot. Ges. Bd. 20, S. 7. 1907.



KÖLREUTER. STRASBURGER<sup>1)</sup> fand, dass das Pollenkorn derselben dikotyledonischen Pflanzen auf dem Stigma einiger monokotyledonischen Pflanzen keimen kann, und er erreichte dasselbe Resultat sogar beim umgekehrten Fall. TOKUGAWA<sup>2)</sup> zeigte kürzlich, dass das Pollenkorn einer Species, sowohl bei der monokotyledonischen als auch bei der dikotyledonischen Gruppe, bis zu einer gewissen Länge auf dem Stigma einer anderen Species derselben Gruppe keimen kann.

Andererseits untersuchte HILDEBRAND<sup>3)</sup> einige Cruciferae und erklärte, dass *Aethionema*, *Hesperis*, *Hugueninia* und *Cardamine* selbststeril seien, dass aber bei *Rapistrum* und *Iberis* die Wirkung der Selbstbefruchtung vorteilhafter sei. JOSE<sup>4)</sup> sagte, dass im Falle von Selbststerilität das Pollenkorn auf dem Stigma nicht keimen und dass der Pollenschlauch nur wachsen könne, wenn das Stigma zerdrückt sei, dass jedoch der Schlauch den Fruchtknoten nicht erreichen könne. Überdies fand er, dass es einen grossen Unterschied zwischen Kreuz- und Selbstbefruchtung giebt, in Bezug auf Wachsgeschwindigkeit von Pollenschläuchen im Gynaeceum.

In der von mir studierten Literatur bestehen verschiedene Ansichten über die Wirksamkeit von Kreuz- und Selbstbefruchtung. Einige Autoren geben an, dass Selbstbefruchtung keine Kapseln hervorbringe, während Andere der Meinung sind, dass Kreuzbefruchtung wirksamer sei als Selbstbefruchtung. Soweit ich nach den Resultaten früherer Untersuchungen beurteilen kann,

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1) STRASBURGER, E.: Über fremdartige Bestäubung. Jahrb. f. wiss. Bot. Bd. 17, S. 50, 1886.

2) TOKUGAWA, Y.: Zur Physiologie des Pollens. Jour. Coll. Sc. Imp. Univ. Tokyo, Vol. 35, Art. 8, 1911.

3) HILDEBRAND, F.: Einige biologische Beobachtungen. Ber. d. Bot. Ges., Bd. 14, S. 321 1886.

4) JOSE, L.: Über die Selbststerilität einiger Blüten. Bot. Ztg., Bd. 65, S. 77, 1907.



ist die Wirkung von Kreuz- und Selbstbefruchtung nicht absoluter sondern relativer Natur.

In der Absicht, einige Beiträge über diese Frage zu liefern, und diese relative Wirksamkeit der verschiedenen Befruchtungsarten bei einigen japanischen Pflanzen, besonders bei gezüchteten, zu erforschen, machte ich die vorliegende Arbeit in den akademischen Jahren 1916-1918 im botanischen Institut der kaiserlichen Universität zu Tokyo, unter Leitung von Herrn Professor Dr. MIYOSHI, dem ich an dieser Stelle meinen verbindlichsten Dank ausspreche. Ich bin auch den Herren Dr. HIBINO, Dr. KUWADA und Dr. TAHARA für ihre wertvollen Auskünfte, den ganzen Fortschritt der Arbeit hindurch, zu Dank verbunden.

## II. Methode.

Bei den Fällen von Xenogamie und Geitonogamie öffnete und kastrierte ich die Blume vorsichtig mit einer sehr feinen Pincette vor der Blütezeit; im Falle von Autogamie wartete ich auf das Aufspringen der Anthere.

Zum Säen von Pollenkörnern auf das Stigma gebrauchte TSCHERMAK<sup>1)</sup> Stahlschreibfedern, aber ich legte den aufgesprungenen Staubbeutel mit der Pincette darauf. Nach dem Bestäuben benützte ich Papierhüllen zum Schutz gegen Insekten; wenn das bestäubte Stigma verwelkt war, entfernte oder zerriss ich die Hülle, weil das Bedecken der Blume die Entwicklung der Kapseln beeinflusst; diese Erfahrung machte ich bei *Calystegia sepium* R. BR. var. *japonica* MAK. und zwei Garten-Varietäten von *Prunus serrulata* LINDL., welche keine Kapseln hervorbrachten.

Sorgfalt wurde darauf verwandt, dass die Samen vollkommen

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1) TSCHERMAK, F : l. c. S. 11.

reiften, ehe sie gesammelt wurden. In einigen Fällen sprangen die Kapseln jedoch auf, sobald sie reif waren. Ich schnitt deshalb den Stengel einige cm vom Boden ab und hing ihn im Zimmer umgekehrt auf, um die Samen reifen zu lassen. Später wurden sie gemessen.

Zwecks Wiegen legte ich die Samen in das Wageglas, erhitzte sie zwei mal bei 100° C eine oder zwei Stunden lang und stellte alsdann das die getrockneten Samen enthaltende Glas zur Abkühlung in einen Trockenapparat. Nach drei oder vier Stunden wurden die Samen gewogen. Diese Methode wurde angewandt, wenn ich zahlreiche Samen bei den Befruchtungen erzielte; wenn aber die Samen weniger an Zahl waren, wog ich sie alle ohne irgend eine Behandlung und nahm den Durchschnitt.

In Bezug auf das Keimen der Samen folgte ich YOSHII'S Methode.<sup>1)</sup> An Stelle von Filtrierpapier benützte ich chemisch reine und mit fließendem Wasser gewaschene Baumwolle. Die PETRISCHEN Schalen wurden zuerst durch Hitze sterilisiert. Nachdem Baumwolle daraufgelegt war, stellte ich sie in den Dampfsterilisator. Nach dem Säen wurden die Deckel der Schalen durch Glasdreifüsse gehalten, um den Abzug des respirierten Gases zu ermöglichen. Bei den Samen, welche durch obenerwähnte Methode nicht keimten, wiederholte ich das Experiment, indem ich sterilisierten Sand benützte. Nach Abkühlen des Sandes tauchte ich den Behälter in Wasser und säte die Samen wie in den PETRISCHEN Schalen, wobei ich Xenogamie, Geitonogamie und Autogamie klassifizierte.

Im histologischen Verfolge, sammelte ich die Materialien nach der Operation und fixierte sie sofort. Bei der gewöhnlichen

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1) YOSHII, Y.: Zur Keimungsphysiologie der Samen einiger Küstenpflanzen. (Japanisch.) Bot. Mag. Tokyo, Vol. 30, S. 377, 1916.

Methode machte ich die serienweisen mikrotomischen Sektionen 10-12  $\mu$  dick. Als Fixiermedia wurden hauptsächlich CARNOYS Flüssigkeit, Chrom-Essigsäure und FREMMINGS Lösung verwandt. Zum Färben benützte ich FREMMINGS Safranin-Gentianaviolett-Orange-G, HEIDENHAINS Eisen-Alum-Hämatoxylin und Lichtgrün. Von den beiden, wurde das letztere besonders gebraucht.

### III. Versuchsangaben.

#### 1) *Primula sinensis* LINDL.

Bekannterweise sind die von DARWIN<sup>1)</sup> und HILDEBRAND<sup>2)</sup> studierten Species heterostielige Pflanzen mit dimorphen Blumen.

Viele Autoren untersuchten den Dimorphismus von Blumen. Bei den dimorphen Blumen ist das Pollenkorn der langstieligen Blumen bedeutend kleiner als das der kurzstieligen, während bei ersteren die Stigma-Papillen bedeutend grösser sind als bei letzteren.

Laut der Resultate der Experimente von DARWIN und HILDEBRAND ergeben die gewöhnlich durch Insekten hervorgerufenen legitimen Befruchtungen eine grössere Quantität von Samen, als die illegitimen Befruchtungen. Der Unterschied in der Fruchtbarkeit zwischen legitimen und illegitimen Befruchtungen variiert nach den verschiedenen Species. Wenn die legitimen Befruchtungen vor sich gegangen sind, ist der Grad der Fruchtbarkeit nicht immer gleich; einige Pflanzen haben viel Fruchtbarkeit und andere weniger.

Der Grössenunterschied des Pollenkornes wird als Anpassung an die Länge des Stieles angesehen, da bei natürlicher Wahl die Grösse des Pollenkorns sich nach der durch den Pollenschlauch

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1) DARWIN, CH.: The effects of cross- and self-fertilisation etc. S. 225 und The different forms of flowers etc. S. 38.

2) HILDEBRAND, F.: Experimente über den Dimorphismus von *Linum perenne* und *Primula sinensis*. Bot. Ztg., Bd. 22, S. 1, 1864.

bei legitimer Kreuzung zurückzulegenden Entfernung richtet. Da ferner die Stigma-Papillen an die Grösse der Pollenkörner, welche sie zu empfangen haben, angepasst sind, so folgt, dass Geschlechtsorgane, welche sich auf ungleichartigen Höhen befinden, für einander unpassend sind, und dass somit die illegitime Kreuzung von heterostieligen Blumen unfruchtbar sein würde.

Sowohl DARWIN wie HILDEBRAND machten Befruchtungen über Fruchtbarkeit, sowie Zahl und Gewicht von Samen.

DARWIN giebt uns keine Erklärung über die Beziehung von befruchtenden Blumen, aber wir finden diesbezügliche Verzeichnungen von HILDEBRAND vor.

DARWIN<sup>1)</sup> giebt an, dass bei legitimer Befruchtung beider Formen die Kapseln der kurzstieligen Pflanzen durchschnittlich mehr Samen enthalten, als die der langstieligen, und zwar im Verhältnis von 12,2 zu 9,3; nach dem Gewicht 100 zu 78. Das Verhältnis der Fruchtbarkeit der zwei legitimen Befruchtungen zu denen der zwei illegitimen Befruchtungen ist wie 100 zu 84. Wenn man das Durchschnittsgewicht der durch die zwei Arten von Befruchtungen erzeugten Samen für jede Kapsel in Betracht zieht, so ist das Verhältnis wie 100 zu 63. Das Verhältnis für die Anzahl von Samen, welche durch die beiden legitimen Befruchtungen erzeugt wurden, verglichen mit den illegitimen Befruchtungen, ist 100 zu 53.

Gemäss HILDEBRANDS<sup>2)</sup> Resultaten haben im Falle von illegitimer Xenogamie alle Blumen Kapseln hervorgebracht, während bei Autogamie aus 100 bestäubten Blumen nur 67 Kapseln erzeugt wurden.

Ich machte verschiedene Kombinationen von langen und kurzen

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1) DARWIN, CH.: The different forms of flowers etc. S. 39-40.

2) HILDEBRAND, F.: l. c. S. 3.

Stielen, welche in drei Arten von Befruchtungen vorkommen, nämlich :

Xenogamie,

befruchtend, langstielige × kurzstielige	Form	(L × K) <sup>1)</sup>
„ , kurzstielige × langstielige	„	(K × L)
„ , langstielige × langstielige	„	(L × L)
„ , kurzstielige × kurzstielige	„	(K × K)

Geitonogamie,

befruchtend, langstielige	Formen	(L)
„ , kurzstielige	„	(K)

Autogamie,

befruchtend, langstielige	Formen	(L)
„ , kurzstielige	„	(K)

Bei diesen acht Fällen sind die ersten zwei legitime Befruchtungen und die übrigen illegitime.

Ich gebrauchte zehn Exemplare für das Experiment und beobachtete die Entwicklung der Kapseln jeden vierten Tag. Ich fand hierbei, dass die Kapseln von legitimen Befruchtungen besser wachsen als solche von illegitimen Befruchtungen. Diese Tatsache stimmt mit dem Resultat von DARWIN und HILDEBRAND überein. Das Wachstum von Kapseln bei illegitimer Befruchtung ist nicht so hochgradig schlecht, im Vergleich mit dem Wachstum von Kapseln, welche wir im Falle von legitimer Befruchtung wahrnehmen (Tabelle I). Ich habe den Wuchs von Kapseln, langsam wie er ist, einen Monat lang beobachtet und erfahren, dass sogar bei legitimer Befruchtung die langstieligen Formen zu stärkerem Wachstum als die kurzstieligen neigen. Das Resultat meiner Beobachtungen ist wie folgt :

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1) Ich gebrauchte diese Abkürzung bei weiteren Beschreibungen.

Befruchtung		Am 12ten Tage nach der Bestäubung		Am 30sten Tage nach der Bestäubung	
		Länge der Kapsel in cm	Weite der Kapsel in cm	Länge der Kapsel in cm	Weite der Kapsel in cm
Xenogamie	L × K	0.49	0.50	0.75	0.80
	K × L	0.25	0.35	0.65	0.70
	L × L	0.25	0.45	0.70	0.80
	K × K	0.25	0.35	0.50	0.70
Geitonogamie	L	0.30	0.40	0.60	0.70
	K	0.30	0.45	0.60	0.70
Autogamie	L	0.25	0.35	0.60	0.70
	K	0.25	0.50	0.60	0.75

Wie aus obiger Tabelle ersichtlich ist, erhielt ich ein ganz verschiedenes Resultat von denjenigen DARWINS und HILDEBRANDS. Bei einem Falle von xenogamischer Befruchtung (L × K) erhielt ich Kapseln in Höhe von 83% der bestäubten Blumen; beim anderen Falle (K × L) 77%. Bei den illegitimen xenogamischen Befruchtungen erhielt ich in einem Falle (L × L) Kapseln in Höhe von 83% der bestäubten Blumen, im anderen (K × K) 80%; bei Geitonogamie (L) 27% und (K) 50%; bei Autogamie (L) 90% und (K) 70%.

Beim Prüfen von 975 Kapseln, in welchen 4772 gereifte Samen enthalten waren, erhielt ich nachstehende Tabelle:

Befruchtung		Länge der Kapseln in cm	Weite der Kapseln in cm	Anzahl von Samen in einer Kapsel
Xenogamie	L × K	1.10 — 0.75	1.00 — 0.75	58 — 14
	K × L	1.00 — 0.66	0.85 — 0.60	69 — 29
	L × L	0.80 — 0.60	0.85 — 0.60	34 — 10
	K × K	0.90 — 0.40	0.90 — 0.50	57 — 9



Geitonogamie	L	0.85 — 0.40	0.85 — 0.50	35 — 2
	K	0.90 — 0.50	0.90 — 0.50	39 — 3
Autogamie	L	0.80 — 0.35	0.87 — 0.40	46 — 1
	K	0.95 — 0.70	0.90 — 0.65	33 — 10

In Bezug auf die Durchschnittslänge und -Weite von Kapseln und die Durchschnittszahl von Samen fand ich, dass legitime Xenogamie wirksamer ist, als illegitime Xenogamie, Geitonogamie und Autogamie. Wenn man hierbei das Durchschnittsgewicht der Samen in Betracht zieht, so kommt man zum Schluss, dass illegitime Xenogamie schwerere Samen als Geitonogamie und Autogamie hervorbringt (Tabelle IV).

Wenn wir nun die Wirkung eines Falles von Xenogamie (L X K), zwecks leichterem Vergleichung mit den anderen Befruchtungen, als 100 annehmen, so erhalten wir die folgenden Zahlen:

Befruchtung		Fruchtbarkeit	Länge der Kapsel	Weite der Kapsel	Anzahl von Samen in einer Kapsel	Gewicht der Samen
Xenogamie	L × K	100.0	100.0	100.0	100.0	100.0
	K × L	92.7	88.8	87.9	113.5	63.8
	L × L	100.0	75.9	89.0	54.0	84.2
	K × K	96.3	72.4	81.9	81.0	98.8
Geitonogamie	L	32.5	72.4	84.3	59.4	101.8
	K	60.2	63.4	74.6	45.9	82.4
Autogamie	L	108.1	71.3	83.1	59.4	74.0
	K	84.3	87.7	93.9	64.8	85.1

Im Bezug auf Fruchtbarkeit ist die langstielige Blume bei Autogamie am grössten, während die gleichgeformte Blume bei

Geitonogamie am kleinsten ist; an Länge der Kapsel ist der Fall ( $L \times K$ ) unter Xenogamie am grössten und die kurzstielige Blume bei Geitonogamie am kleinsten. An Weite der Kapsel ist der Fall ( $L \times K$ ) unter Xenogamie am grössten und die kurzstielige Blume bei Geitonogamie am kleinsten. An Anzahl von Samen in einer Kapsel ist der Fall ( $K \times L$ ) unter Xenogamie am grössten und die kurzstielige Blume bei Geitonogamie am kleinsten; an Gewicht der Samen ist die langstielige Blume bei Geitonogamie am grössten, während ( $K \times L$ ) unter Xenogamie am kleinsten ist.

Wenn wir die Wirkung in Bezug auf Autogamie, Geitonogamie und Xenogamie in Berücksichtigung ziehen und die Wirkung von Xenogamie als 100 annehmen, so erhalten wir :

Befruchtung	Fruchtbarkeit	Länge der Kapseln	Weite der Kapseln	Anzahl von Samen in einer Kapsel	Gewicht der Samen
Xenogamie	100.0	100.0	100.0	100.0	100.0
Geitonogamie	47.7	80.6	88.8	43.7	102.1
Autogamie	99.1	94.5	93.5	57.5	91.1

Die Xenogamie ist somit am wirksamsten, mit Ausnahme des Falles von Gewicht der Samen.

## 2) *Primula obconica* HANCE.

Diese Species ist ebenfalls dimorph, und die Beziehung zwischen den Pollenkörnern und den Stigma-Papillen ist gleich wie die Beziehung zwischen den zwei Formen von *Primula sinensis* LINDL.

Ich behandelte *Primula obconica* HANCE in gleicher Weise wie

*P. sinensis*, d. h. ich machte verschiedene Kombinationen von lang- und kurzstieligen Blumen, indem ich 10 Stämme benützte.

Bei legitimer Xenogamie erzeugte ein Fall ( $L \times K$ ) Kapseln in Höhe von 94% der bestäubten Blumen und ein anderer Fall ( $K \times L$ ) 82%; ferner wurden erzeugt: bei illegitimer Xenogamie in einem Falle ( $L \times L$ ) 23%, im anderen ( $K \times K$ ) 28%; bei Geitonogamie in einem Falle (L) 9%, im anderen (K) 8%; bei Autogamie in einem Falle (L) 11% und im anderen (K) 6%.

Es ist somit klar, dass die legitimen Befruchtungen ( $L \times K$ ) und ( $K \times L$ ) gute Fruchtbarkeit vorstellen. Die zwei legitimen Befruchtungen sind sehr produktiv, und ich erhielt Kapseln in Höhe von 99% der bestäubten Blumen. Bei den illegitimen Befruchtungen ist die Produktion hingegen gering, und ich erhielt nur 15.5% Kapseln.

Ich beobachtete das Wachstum der Kapseln jeden vierten Tag. (Das Resultat ist aus Tabellen II und III ersichtlich.) Der Wuchs der Kapseln ist nicht stark. Die Länge und Weite nahmen allmählich eine Woche lang zu, und nachher wuchsen die Kapseln verhältnismässig mehr in die Weite als in die Länge. Ungefähr einen Monat nach der Bestäubung hörte das Wachstum der Kapseln fast ganz auf, und die Samen in den Kapseln fingen an zu reifen.

Der grosse Unterschied zwischen der Legitimität und Illegitimität der Befruchtungen lässt sich aus Tabellen II und III ersehen. Hierbei waren die legitim befruchteten Kapseln sehr gut in Bezug auf Fruchtbarkeit und Wachstum, während die illegitim befruchteten beinahe degenerierten. Ich kam zu folgendem Resultat:

Befruchtung		Am 12ten Tage nach der Bestäubung		Am 30sten Tage nach der Bestäubung	
		Länge der Kapsel in cm	Weite der Kapsel in cm	Länge der Kapsel in cm	Weite der Kapsel in cm
Xenogamie	L × K	0.20	0.30	0.30	0.50
	K × L	0.20	0.25	0.25	0.30
	L × L	0.20	0.25	0.25	0.30
	K × K	0.20	0.25	0.20	0.25
Geitonogamie	L	0.20	0.25	—	—
	K	0.20	0.25	—	—
Autogamie	L	0.20	0.25	—	—
	K	0.20	0.30	0.25	0.35

Bei den legitimen Befruchtungen wuchsen die Kapseln 0.5 cm in vier Tagen, besonders in die Breite. Bei den illegitimen Befruchtungen degenerierten jedoch die meisten Kapseln; sie wuchsen nicht nach beiden Dimensionen, und ihre Entwicklung war sehr langsam.

Ich untersuchte 138 Kapseln, welche 5199 Samen enthielten, und erhielt folgendes Resultat:

Befruchtung		Länge der Kapseln in cm	Weite der Kapseln in cm	Anzahl von Samen in einer Kapsel
Xenogamie	L × K	0.40 — 0.30	0.60 — 0.45	125 — 1
	K × L	0.55 — 0.15	0.70 — 0.20	150 — 1
	L × L	0.40 — 0.15	0.50 — 0.15	20 — 1
	K × K	0.35 — 0.15	0.35 — 0.20	4 — 1
Geitonogamie	L	0.40 — 0.25	0.45 — 0.40	6 — 1
	K	0.25 — 0.20	0.35 — 0.25	4 — 1

Autogamie	L	0.35 — 0.50	0.50 — 0.20	3 — 1
	K	0.35 — 0.30	0.45 — 0.20	11 — 2

In Bezug auf den Durchschnitt dieser Resultate erhalten wir nachstehende Zahlen, wobei im Fall von Xenogamie ( $L \times K$ ) als 100 angenommen ist:

Befruchtung		Fruchtbarkeit	Länge der Kapsel	Weite der Kapsel	Anzahl von Samen in einer Kapsel	Gewicht der Samen
Xenogamie	$L \times K$	100.0	100.0	100.0	100.0	100.0
	$K \times L$	87.2	94.4	97.9	86.2	107.6
	$L \times L$	24.4	65.7	59.1	5.8	3.8
	$K \times K$	29.7	57.8	55.0	1.9	11.5
Geitonogamie	L	9.5	89.4	83.6	3.9	15.3
	K	8.5	57.8	61.2	3.9	15.3
Autogamie	L	11.7	81.5	77.7	1.9	11.5
	K	6.3	86.8	77.7	11.9	11.5

An Fruchtbarkeit ist die Länge und Weite der Kapseln und die Anzahl von Samen in den Kapseln beim Falle ( $L \times K$ ) unter Xenogamie am grössten, aber in Bezug auf Gewicht der Samen ist der Fall ( $K \times L$ ) unter Xenogamie am höchsten.

Beim Vergleich der 3 Befruchtungsarten—Xenogamie, Geitonogamie und Autogamie—erhalten wir das folgende Resultat, indem wir Xenogamie als 100 annehmen:

Befruchtung	Fruchtbarkeit	Länge der Kapseln	Weite der Kapseln	Anzahl von Samen in einer Kapsel	Gewicht der Samen
Xenogamie	100.0	100.0	100.0	100.0	100.0

Geitonogamie	14.9	92.7	92.9	8.0	27.5
Autogamie	14.9	105.9	99.4	14.1	20.6

Xenogamie ist hiernach die wirksamste unter diesen Befruchtungen, ausgenommen den Fall von Weite der Kapsel.

3) *Brassica campestris* L.

*subsp. chinensis* MAKINO.<sup>1)</sup>

a) Messen der Kapseln und Samen.

Ich gebrauchte 14 Exemplare für das Experiment und erhielt 1349 Kapseln und 36904 Samen. Nachstehende Liste zeigt das Resultat:

Befruchtung	Länge der Kapseln in cm	Weite der Kapseln in cm	Anzahl von Samen in einer Kapsel
Xenogamie	8.00 — 2.80	0.75 — 0.45	45 — 2
Geitonogamie	7.89 — 2.20	0.75 — 0.40	43 — 2
Autogamie	7.70 — 1.80	0.70 — 0.40	41 — 2

Der Vergleich des Durchschnittes ist, bei der Annahme von Xenogamie als 100, wie folgt:

Befruchtung	Fruchtbarkeit	Länge der Kapseln	Weite der Kapseln	Anzahl von Samen in einer Kapsel	Gewicht der Samen
Xenogamie	100.0	100.0	100.0	100.0	100.0

1) Bei derartigen Cruciferae ist es äusserst umständlich, jede einzelne Blume zu bedecken. Deshalb benützte ich einen von einem leichten Stäbchen gehaltenen Korb mit weiten Maschen, bedeckte die ganze Infloreszens damit und unwickelte ihn dann mit Gaze.



Geitonogamie	92.3	98.0	100.0	100.0	96.5
Autogamie	74.7	95.5	98.1	96.2	93.1

Die Xenogamie ist infolgedessen in jeder Beziehung die wirksamste dieser drei Befruchtungsarten. (Taf. I, Fig. 1.)

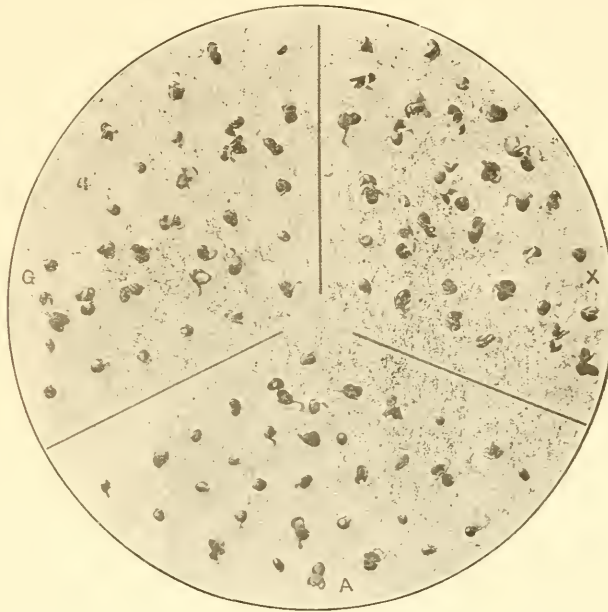


Fig. 1. Keimung der Samen von *Brassica campestris* L. subsp. *chinensis* MAX.

X) Xenogamie, G) Geitonogamie und A) Autogamie.

#### b) Keimen der Samen.

Mit dem bereits erwähnten Apparate beobachtete ich vier mal, indem ich jede Schale verdoppelte. Im ganzen wurden 2532 Samen bei Zimmertemperatur gesät. Das Resultat war wie folgt:

Befruchtung	Anzahl von Samen gesamt	Anzahl von Samen gekeimt	Prozentsatz der Keimung
Xenogamie	844	812	99.8
Geitonogamie	844	827	97.9
Autogamie	844	826	97.8

Somit keimten die xenogamischen Samen mehr als die anderen. (Textfig. 1.)

#### 4) „*Komatsuna*.“<sup>1)</sup>

##### a) Messen der Kapseln und Samen.

Acht Exemplare wurden für das Experiment benützt, und ich erhielt 594 Kapseln, welche 13422 Samen enthielten. Die Prüfung ergab folgende Tabelle:

Befruchtung	Länge der Kapseln in cm	Weite der Kapseln in cm	Anzahl von Samen in einer Kapsel
Xenogamie	6.90 — 3.00	0.80 — 0.45	35 — 7
Geitonogamie	6.50 — 1.70	0.70 — 0.35	35 — 2
Autogamie	6.50 — 1.20	0.60 — 0.30	34 — 1

Der Vergleich des Durchschnittes zeigt, bei Annahme von Xenogamie als 100, folgende Zahlen:

Befruchtung	Frucht- barkeit	Länge der Kapseln	Weite der Kapseln	Anzahl von Samen in einer Kapsel	Gewicht der Samen
Xenogamie	100.0	100.0	100.0	100.0	100.0

1) Eine Varietät von *Brassica campestris* L. subsp. *chinensis* MAKINO.

Geitonogamie	87.6	89.3	76.2	87.5	100.0
Autogamie	83.6	90.9	89.8	87.5	97.0

Somit ist die Xenogamie in jeder Beziehung am wirksamsten unter diesen Befruchtungsarten.

b) Keimen der Samen.

Ich säte die Samen wie zuvor, indem ich immer verdoppelte. Im ganzen studierte ich mit 2052 Samen, die meistens am näch-

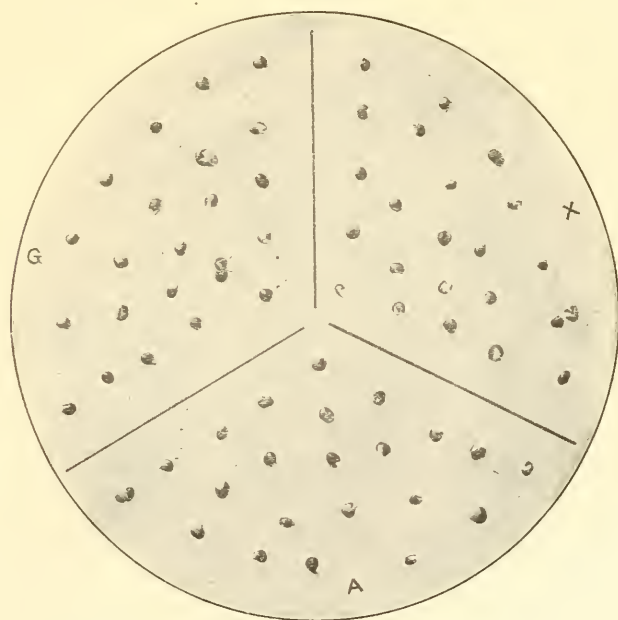


Fig. 2. Keimung der Samen von „Komatsuna“; X) Xenogamie, G) Geitonogamie und A) Autogamie.

sten Tage keimten. Die xenogamischen Samen keimten mehr als die anderen. (Textfig. 2.)

Befruchtung	Anzahl von Samen gesamt	Anzahl von Samen gekeimt	Prozentsatz der Keimung
Xenogamie	684	684	100.0
Geitonogamie	684	675	98.6
Autogamie	684	678	99.1

5) *Brassica campestris* L.*subsp. chinensis* MAKINO*var. Toona* MAKINO.

## a) Messen der Kapseln und Samen.

Ich gebrauchte 14 Exemplare für das Experiment, von denen 6 in dem Treibhaus gezüchtet wurden und im Januar 1917 blühten. Die übrigen wurden auf gewöhnliche Weise gezüchtet.

Ich untersuchte 2222 Kapseln, welche 14483 Samen enthielten, und erhielt folgendes Resultat:

Befruchtung	Länge der Kapseln in cm	Weite der Kapseln in cm	Anzahl von Samen in einer Kapsel
Xenogamie	4.50 — 2.30	0.75 — 0.50	27 — 3
Geitonogamie	4.50 — 2.00	0.75 — 0.45	27 — 2
Autogamie	4.00 — 1.50	0.70 — 0.45	26 — 1

Wenn wir den Durchschnitt ziehen, und unter Annahme von 100 für Xenogamie, die Befruchtungen vergleichen, so ergibt sich:

Befruchtung	Fruchtbarkeit	Länge der Kapseln	Weite der Kapseln	Anzahl von Samen in einer Kapsel	Gewicht der Samen
Xenogamie	100.0	100.0	100.0	100.0	100.0
Geitonogamie	80.0	103.1	93.7	84.6	125.0
Autogamie	77.0	94.3	98.4	76.9	137.5

Wie ersichtlich ist, ist Xenogamie an Fruchtbarkeit (Taf. I, Fig. 2), Weite der Kapsel und Zahl der Samen in einer Kapsel günstiger als die anderen Arten, jedoch ist Geitonogamie am besten in Bezug auf Länge der Kapsel, und Autogamie am besten in Bezug auf Gewicht der Samen.

b) Keimen der Samen.

Ich untersuchte im ganzen 2136 Samen in drei Experimenten und erhielt folgendes Resultat:

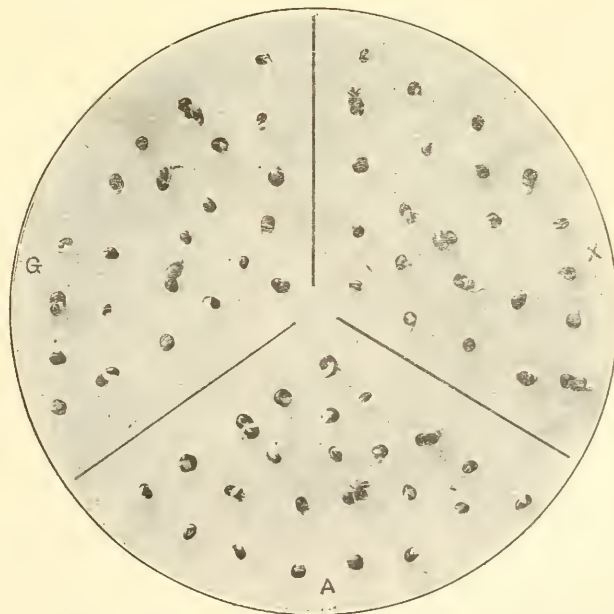


Fig 3. Keimung der Samen von *Brassica campestris* L. subsp. *chinensis* MAK. var. *Toona*. MAK; X) Xenogamie, G) Geitonogamie und A) Autogamie.

Befruchtung	Anzahl von Samen gesamt	Anzahl von Samen gekeimt	Prozentsatz der Keimung
Xenogamie	712	708	99.4
Geitonogamie	712	700	98.3
Autogamie	712	696	77.7

Die xenogamischen Samen keimten demgemäss mehr als die anderen Befruchtungen. (Textfig. 3.)

c) Entwicklung des Embryo.

In der anatropen Samenanlage vervielfältigt sich die Embryosackmutterzelle durch die successive Teilung, und wenn der Embryosack fast vollendet ist, erscheinen zwei Synergiden, eine Eizelle und zwei Polkerne. Die Antipoden entwickeln sich nicht

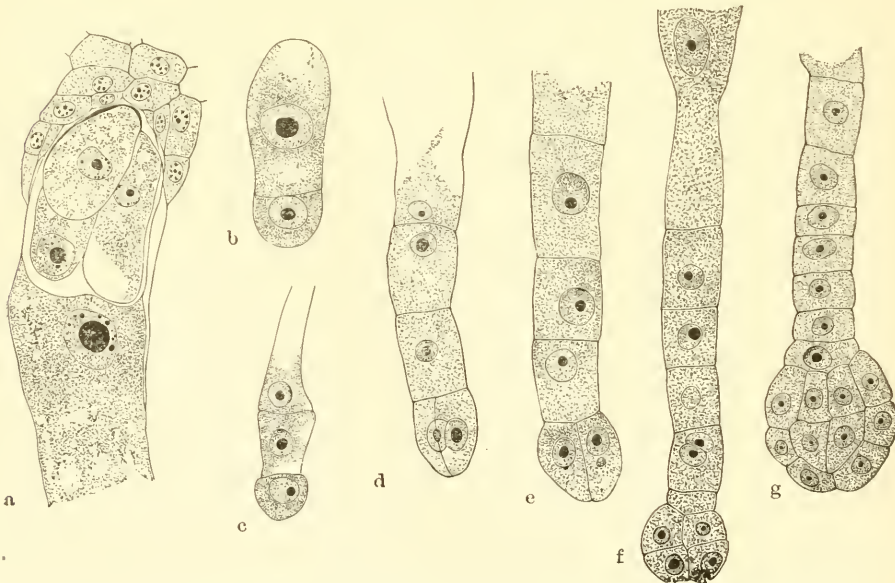


Fig. 4. Die verschiedenen Stadien des entwickelnden Embryo von *Brassica campestris* L. subsp. *chinensis* MAK. var. *Toona* MAK. a) Der obere Teil des reifen Embryosacks. b) 2 Tochterzellen von der Eizelle. c) Das 3-zellige Stadium. d) Die erste Teilung der Terminalzellen. e) Das Quadrant Stadium. f) Das Oktant Stadium. g) Das Differenzieren von Dermatogen.



wie einige andere Species. Alsdann verschmelzen die Polkerne in einen grossen Kern (Textfig. 4 a).

Zwei Tage nach der Bestäubung erreichte der Pollenschlauch den Fruchtknoten nicht in jedem Falle von Befruchtung. Bei Xenogamie wurde die Eizelle nach 4 Tagen befruchtet, aber nicht geteilt. Ich fand viele Endospermkerne. Sowohl bei Geitonogamie als auch bei Autogamie gewahrte ich dasselbe Stadium, wie ich es in den 2 Tagen nach der Bestäubung beobachtete. Deshalb können wir annehmen, dass bei Xenogamie die Befruchtung am dritten Tage nach der Bestäubung vor sich geht. 6 Tage später wurden bei Xenogamie einige der Eizellen in 2 Tochterzellen geteilt (Textfig. 4 b), und der grössere Teil derselben nahm 3-zelliges Stadium an (Textfig. 4 c). Dagegen fand ich bei Geitonogamie und Autogamie die Eizellen ungeteilt, obgleich sie bereits befruchtet worden waren. Sie blieben sieben Tage lang unverändert. Am zehnten Tage fand ich 3-zelliges Stadium bei Geitonogamie. Bei Xenogamie teilte sich die Terminalzelle des 3-zelligen Embryos am zwölften Tage zwei mal und nahm Quadrant Stadium an (Textfig. 4 e). Bei Autogamie hatte der Embryo bereits das 3-zellige Stadium durchgemacht, und seine Terminalzelle war geteilt (Textfig. 4 d). Am fünften Tage begann der Embryo bei Xenogamie das Dermatogen zu differenzieren, und perikline Teilung zeigte sich im Terminal - Oktant



Fig. 5. Der junge Embryo von *Brassica campestris* L. subsp. *chinensis* MAE. var. *Tsoma* MAE

(Textfig. 4 g), während der geitonogamische Embryo sich im Oktant Stadium befand. Der xenogamische Embryo zeigte am zwölften Tage starkes Wachstum, und ich konnte Kotyledon, welches das Plerom, Peribrem und Dermatogen differenzierte, unterscheiden (Fig. 5). Somit ereignet sich die Befruchtung bei Xenogamie am frühesten, indem der Embryo am günstigsten gedeiht, wodurch er stets in vorgerücktem Stadium ist.

6) *Brassica campestris* L.

*subsp. rapa* Hook. FIL. et ANDS.

a) Messen der Kapseln und Samen.

Ich gebrauchte 6 Exemplare für das Experiment und erhielt 522 Kapseln und 8371 Samen, laut folgender Liste :

Befruchtung	Länge der Kapseln in cm	Weite der Kapseln in cm	Anzahl von Samen in einer Kapsel
Xenogamie	6.80 — 2.00	0.65 — 0.30	34 — 1
Geitonogamie	6.00 — 2.10	0.65 — 0.30	33 — 1
Autogamie	6.20 — 2.20	0.60 — 0.30	30 — 1

Beim Vergleich der Durchschnittszahlen, erhalten wir, unter Annahme von Xenogamie als 100, folgende Zahlen :

Befruchtung	Frucht- barkeit	Länge der Kapsel	Weite der Kapsel	Anzahl von Samen in einer Kapsel	Gewicht der Samen
Xenogamie	100.0	100.0	100.0	100.0	100.0
Geitonogamie	94.6	92.4	89.3	93.7	48.1
Autogamie	93.6	96.1	95.7	100.0	80.0

Also ist die Xenogamie am wirksamsten in jeder Beziehung.

b) Keimen der Samen.

Die Experimente wurden immer verdoppelt und 3 mal studiert. Ich untersuchte im ganzen 2208 Samen, und die xenogamischen keimten im allgemeinen besser als die anderen, laut folgendem Resultat:

Befruchtung	Anzahl von Samen gesät	Anzahl von Samen gekeimt	Prozentsatz der Keimung
Xenogamie	736	731	99.7
Geitonogamie	733	720	97.8
Autogamie	736	722	98.0

7) *Tricyrtis hirta* Hook.

7) Messen der Kapseln und Samen.

Zehn Exemplare wurden für das Experiment gebraucht und nur auf Autogamie und Xenogamie untersucht. Sie zeigten keinen sichtbaren Unterschied von einander in Bezug auf Wachstum der Kapseln. 37 Kapseln, die 625 Samen enthielten, wurden untersucht. Das Resultat war wie folgt:

Befruchtung	Länge der Kapseln in cm	Durchschnitts- länge der Kapseln in cm	Anzahl von Samen in einer Kapsel	Durchschnitts- anzahl von Samen in einer Kapsel	Durchschnitts- gewicht der Samen in g
Xenogamie	3.00-2.70	2.90	390-147	187	0.0000117
Autogamie	3.20-2.50	2.60	286- 5	142	0.0000102

Indem wir als Durchschnittszahl für Xenogamie 100 annehmen, erhalten wir die nachstehende Liste:

Befruchtung	Länge der Kapsel in cm	Weite der Kapsel in cm	Anzahl von Samen in einer Kapsel
Xenogamie	100.0	100.0	100.0 *
Autogamie	89.6	77.5	87.0

Die Xenogamie ist dementsprechend in jeder Beziehung wirksamer als Autogamie.

#### b) Keimen der Samen.

Ich machte mein erstes Experiment über Keimen der Samen am 8. Dezember 1916, indem ich alle Samen einer Kapsel für jeden Fall in die grosse Schale legte. Am 21. Dez. hatten noch keine Samen gekeimt. Alsdann stellte ich die Schalen in den Brutapparat (25° C) und fand am 26. Dez., dass einige gekeimt hatten. Das Experiment war mir jedoch misslungen, und ich gab deshalb alle Vorbereitungen auf, mit Ausnahme einer Schale, um das Austrocknen der Baumwolle zu verhüten. Ich habe hierbei die Wahrnehmung gemacht, dass die Samen dieser Species im Naturlauf durch das Zerspringen der Kapsel gegen Mitte oder Ende November zu Boden fallen, und dass sie nicht vor dem Frühling keimen. Sie gebrauchen also einen gewissen Zeitraum zum Keimen.

Am 24. April 1917 fand ich auf der Schale 12 und am 7. Mai 28 gekeimte Samen.

Die Tatsache, dass die Samen von *Tricyrtis hirta* Hook eine gewisse Ruhepause zum Keimen benötigen, stimmt mit meiner Ansicht überein.

Ich säte die Samen 4 mal, verdoppelte jedes Experiment und erhielt zusammen 400 Samen laut nachstehender Spezifikation:

Befruchtung	Anzahl von Samen gesät	Anzahl von Samen gekeimt	Prozentsatz der Keimung
Xenogamie	200	163	81.5
Autogamie	200	91	45.5

Die xenogamischen Samen haben somit besser als die autogamischen gekeimt.

### 8) *Hyacinthus orientalis* L.

#### a) Messen der Kapseln und Samen.

Es ist unrichtig, die Wirkung von Xenogamie an Hand derselben gefärbten Blumen zu prüfen, es sei denn, dass die Individuen von den Samen herrühren; denn die Zwiebeln stammen von derselben Zwiebel durch Trennung, und die Befruchtung muss in dem Falle gleich mit Geitonogamie sein.

Ich gebrauchte 10 Exemplare für das Experiment. Laut meiner Untersuchung war die Mutterpflanze durch die Bestäubung zwischen der verschieden gefärbten Blumen stark stimuliert und brachte sehr grosse Kapseln hervor. Zum Beispiel bestäubte ich am 22. Februar 1917 drei Blumen autogamisch und geitonogamisch und am 24. Febr. drei Blumen xenogamisch. Als ich sie einen Monat später mass, war die Grösse der Kapseln in den beiden ersten Fällen durchweg kleiner als die der Kapseln der letzteren. Das Resultat war folgendermassen:

Nr.	Xenogamie		Geitonogamie		Autogamie	
	Länge der Kapsel in cm	Weite der Kapsel in cm	Länge der Kapsel in cm	Weite der Kapsel in cm	Länge der Kapsel in cm	Weite der Kapsel in cm
1	1.95	1.55	1.10	1.10	0.95	0.75

2	1.95	1.55	1.00	0.85	1.10	0.90
3	1.75	1.60	—	—	—	—

Ich prüfte 30 Kapseln, in welchen 472 Samen enthalten waren, und erhielt folgende Liste (Tafel. II, Fig. 1):

Befruchtung	Länge der Kapseln in cm	Weite der Kapseln in cm	Anzahl von Samen in einer Kapsel
Xenogamie	2.30 — 1.35	1.75 — 1.30	22 — 1
Geitonogamie	2.10 — 1.20	1.60 — 1.10	20 — 1
Autogamie	2.00 — 1.25	1.70 — 1.20	17 — 1

Bei Annahme von Xenogamie als 100, kommen wir zu folgenden Durchschnittszahlen:

Befruchtung	Frucht- barkeit	Länge der Kapsel	Weite der Kapsel	Anzahl der Samen in einer Kapsel	Gewicht der Samen
Xenogamie	100.0	100.0	100.0	100.0	100.0
Geitonogamie	69.6	93.6	88.9	38.4	116.7
Autogamie	58.4	92.2	93.5	46.1	139.5

Unter diesen Befruchtungen ist Xenogamie in allen Beziehungen am wirksamsten, mit Ausnahme von Gewicht der Samen, wobei Autogamie bessere Resultate erzielte.

#### 9) *Freesia Leichtlini* KLATT.

20 Exemplare wurden benützt und ungefähr Ende Januar in das Gewächshaus gestellt. Nach einem Monat blühten sie.



Die Wirksamkeit von Xenogamie war am besten, und Autogamie kam an zweiter Stelle, aber bei Geitonogamie haben die Blumen keine Kapsel hervorgebracht.

Bei Xenogamie erzielte ich Kapseln in Höhe von 37.5% und bei Autogamie 9.7% der bestäubten Blumen, während Geitonogamie hohe Sterilität repräsentiert.

Das Resultat der geprüften 30 Kapseln und 333 Samen zeigt nachstehende Ziffern (Tafel II, Fig. 2):

Befruchtung	Länge der Kapseln in cm	Weite der Kapseln in cm	Anzahl von Samen in einer Kapsel
Xenogamie	1.80 — 0.75	1.30 — 0.70	30 — 1
Geitonogamie	—	—	—
Autogamie	1.20 — 0.70	1.00 — 0.50	5 — 1

Das Durchschnittsresultat im Vergleich von Autogamie mit der als 100 angenommenen Xenogamie ist wie folgt:

Befruchtung	Frucht- barkeit	Länge der Kapsel	Weite der Kapsel	Anzahl von Samen in einer Kapsel	Gewicht der Samen
Xenogamie	100.0	100.0	100.0	100.0	100.0
Autogamie	25.0	73.2	63.9	15.2	178.0

Also ist Xenogamie wirksamer als Autogamie in vielen Beziehungen, jedoch werden bei Autogamie schwerere Samen hervorgebracht.

#### 10) *Tritonia aurea* PAPP.

##### a) Messen der Kapseln und Samen.

Ich benützte 24 Exemplare für das Experiment und prüfte 60 Kapseln, welche 517 Samen enthielten.

Bei Xenogamie erhielt ich Kapseln in Höhe von 31% der bestäubten Blumen, bei Autogamie 19.8%, aber bei Geitonogamie 33%. Es ist äusserst interessant, dass Geitonogamie die beste Fruchtbarkeit hat, obgleich dies bei anderen Species umgekehrt ist. Ich habe jedoch beim Messen erfahren, dass das Resultat von Geitonogamie ungünstiger als das von Xenogamie ist, wie aus nachstehender Tabelle ersichtlich ist (Tafel I, Fig. 3):

Befruchtung	Länge der Kapseln in cm	Weite der Kapseln in cm	Anzahl von Samen in einer Kapsel
Xenogamie	1.25 — 0.70	0.75 — 0.45	29 — 1
Geitonogamie	1.00 — 0.55	0.60 — 0.40	11 — 1
Autogamie	0.90 — 0.55	0.60 — 0.35	8 — 1

Indem wir als Durchschnittszahl für Xenogamie 100 annehmen, erhalten wir folgende Zahlen:

Befruchtung	Frucht- barkeit	Länge der Kapsel	Weite der Kapsel	Anzahl von Samen in einer Kapsel	Gewicht der Samen
Xenogamie	100.0	100.0	100.0	100.0	100.0
Geitonogamie	106.4	74.6	81.9	20.0	116.0
Autogamie	63.8	73.0	80.3	20.0	121.0

Wie wir sehen, erzeugte Xenogamie längere und weitere Kapseln, sowie eine grössere Anzahl von Samen, während Autogamie schwerere Samen hervorbrachte.

## b) Keimen der Samen.

Wenige Samen wurden bei Autogamie und Geitonogamie gewonnen, wie Tabelle IV zeigt. Ich säte alle Samen in zwei Experimenten. Das Resultat war folgendes:

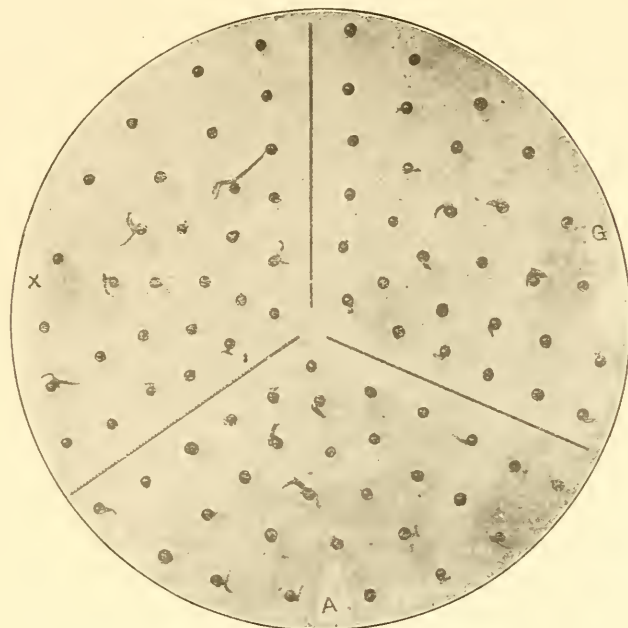


Fig. 6. Keimung der Samen von *Tritonia aurea* PAPP  
X) Xenogamie, G) Geitonogamie und A) Autogamie.

Befruchtung	Anzahl von Samen gesät	Anzahl von Samen gekeimt	Prozentsatz der Keimung
Xenogamie	393	79	20.0
Geitonogamie	69	33	47.8
Autogamie	52	23	44.2

Somit keimten die Samen bei Geitonogamie zahlreicher als die anderen (Textfig. 6).

#### IV. Zusammenfassung.

Durch vorliegende Arbeit kam ich zum Schluss, dass die Xenogamie relativ wirksamer ist als Geitonogamie und Autogamie.

1) Fruchtbarkeit: Bei *Primula sinensis* LINDL., *P. obconica* HANCE., vier Arten von *Brassica*, *Hyacinthus orientalis* L. und *Freesia Leichtlini* KLATT., ist die Xenogamie, und bei *Tritonia aurea* PAPP. die Geitonogamie am wirksamsten, während bei *Freesia Leichtlini* KLATT. keine Kapseln durch Geitonogamie hervorgebracht wurden.

2) Länge der Kapsel: Bei *Primula sinensis* LINDL., *Brassica campestris* L. subsp. *chinensis* MAK. und ihren 2 Varietäten—*rapa* und „*Komatsuna*“, *Tricyrtis hirta* HOOK., *Hyacinthus orientalis* L., *Freesia Leichtlini* KLATT. und *Tritonia aurea* PAPP., erzeugte die Xenogamie, bei *Prim. obconica* HANCE. die Autogamie, und bei einer Varietät von *Brassica*—*Toona* die Geitonogamie die längsten Kapseln,

3) Weite der Kapseln: Bei allen von mir studierten Species und Varietäten, brachte die Xenogamie die weitesten Kapseln hervor.

4) Anzahl der Samen in der Kapsel: Die xenogamischen Kapseln hatten die zahlreichsten Samen bei allen Pflanzen, welche ich prüfte.

5) Gewicht der Samen: Bei *Primula obconica* HANCE., *Brassica campestris* L. subsp. *chinensis* MAK. und ihren 2 Varietäten—*rapa* und „*Komatsuna*“ und *Tricyrtis hirta* HOOK. lieferte die Xenogamie, bei *Prim. sinensis* LINDL. die Geitonogamie und bei einer Varietät von *Brassica*, *Toona*, *Hyacinthus orientalis* L., *Freesia Leichtlini* KLATT. und *Tritonia aurea* PAPP., die Autogamie die schwersten Samen.

6) Keimen von Samen: Bei vier Arten von *Brassica* und *Tricyrtis hirta* Hook. keimten die xenogamischen und bei *Tritonia aurea* PAPP. die geitonogamischen Samen zahlreicher als die anderen Befruchtungsarten.

Tokyo, im November 1918.





Messen des Wuchses der Kapseln von *Primula sinensis* LINDL. vom 22. Februar  
bis 3. April, 1917. Bestäubt am 18. Februar.

Datum der Messung		22/II	26/II	2/III	6/III	10/III	14/III	18/III	22/III	26/III	3/IV
Xenogamie (L × K)	1	Länge 0.20	0.20	0.30	0.35	0.55	0.65	0.65	0.65	0.65	0.65
		Weite 0.20	0.25	0.40	0.50	0.70	0.80	0.80	0.80	0.80	0.80
	2	Länge 0.25	0.35	0.50	0.65	0.75	0.75	0.75	0.75	0.75	0.75
Xenogamie (K × L)	1	Länge 0.20	0.20	0.25	0.30	0.50	0.60	0.65	0.65	0.65	0.65
		Weite 0.20	0.25	0.35	0.55	0.70	0.80	0.80	0.90	0.90	0.90
	2	Länge 0.20	0.20	0.25	0.35	0.50	0.65	0.65	0.65	0.65	0.65
Xenogamie (L × L)	1	Länge 0.25	0.25	0.35	0.55	0.65	0.70	0.70	0.75	0.75	0.75
		Weite 0.20	0.20	0.20	0.30	0.45	0.50	0.55	0.55	0.55	0.55
	2	Länge 0.20	0.25	0.35	0.50	0.55	0.60	0.65	0.65	0.70	0.70
Xenogamie (K × K)	1	Länge 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
		Weite 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
	2	Länge 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
Geitonogamie (L)	1	Länge 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
		Weite 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
	2	Länge 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
Geitonogamie (K)	1	Länge 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
		Weite 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
	2	Länge 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
Autogamie (L)	1	Länge 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
		Weite 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
	2	Länge 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
Autogamie (K)	1	Länge 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
		Weite 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40
	2	Länge 0.15	0.20	0.25	0.35	0.40	0.40	0.40	0.40	0.40	0.40



Tabelle II

Messen des Wuchses der Kapseln von *Primula obconica* HANCE vom 22. Februar  
bis 3. April, 1917. Bestäubt am 18. Februar.

Datum der Messung			22/II	26/II	2/III	6/III	10/III	14/III	18/III	22/III	26/III	3/IV
Xenogamie (L × K)	1	Länge	0,20	0,20	0,20	0,25	0,25	0,30	0,30	0,30	0,30	0,30
		Weite	0,25	0,25	0,30	0,40	0,45	0,50	0,50	0,50	0,50	0,50
	2	Länge	0,15	0,20	0,20	0,25	0,25	0,30	0,30	0,30	0,30	0,30
		Weite	0,20	0,25	0,30	0,40	0,45	0,45	0,50	0,55	0,55	0,55
Xenogamie (K × L)	1	Länge	0,15	0,15	0,20	0,20	0,20	0,20	—	—	—	—
		Weite	0,20	0,20	0,25	0,25	0,25	0,25	—	—	—	—
	2	Länge	0,15	0,15	0,20	0,20	0,20	0,25	0,25	0,30	0,30	0,30
		Weite	0,20	0,20	0,25	0,25	0,25	0,30	0,30	0,35	0,35	0,35
Xenogamie (L × L)	1	Länge	0,20	0,20	0,20	0,20	0,20	0,20	0,25	0,25	0,25	0,25
		Weite	0,25	0,25	0,25	0,25	0,25	0,25	0,30	0,30	0,30	0,30
	2	Länge	0,15	0,20	0,20	0,20	0,20	0,20	—	—	—	—
		Weite	0,20	0,25	0,25	0,25	0,25	0,25	—	—	—	—
Xenogamie (K × K)	1	Länge	0,20	0,20	0,20	0,20	0,20	0,20	—	—	—	—
		Weite	0,25	0,25	0,25	0,25	0,25	0,25	—	—	—	—
	2	Länge	0,15	0,20	0,20	0,20	0,20	0,20	0,20	0,25	0,25	0,25
		Weite	0,20	0,25	0,25	0,25	0,25	0,25	0,25	0,30	0,30	0,30
Geitonogamie (L)	1	Länge	0,15	0,20	0,20	0,20	0,20	0,20	—	—	—	—
		Weite	0,20	0,25	0,25	0,25	0,25	0,25	—	—	—	—
	2	Länge	0,15	0,20	0,20	0,20	0,20	0,20	—	—	—	—
		Weite	0,20	0,25	0,25	0,25	0,25	0,25	—	—	—	—
Geitonogamie (K)	1	Länge	0,15	0,15	0,15	0,15	0,20	0,20	0,20	—	—	—
		Weite	0,20	0,20	0,20	0,20	0,25	0,25	0,25	—	—	—
	2	Länge	0,15	0,20	0,20	0,20	0,20	0,20	—	—	—	—
		Weite	0,20	0,25	0,25	0,25	0,25	0,25	—	—	—	—
Autogamie (L)	1	Länge	0,15	0,20	0,20	0,20	0,20	0,20	—	—	—	—
		Weite	0,20	0,20	0,20	0,25	0,25	0,25	—	—	—	—
	2	Länge	0,15	0,15	0,20	0,20	0,20	0,20	—	—	—	—
		Weite	0,20	0,20	0,25	0,25	0,25	0,25	—	—	—	—
Autogamie (K)	1	Länge	0,15	0,20	0,20	0,25	0,25	0,25	0,25	0,25	0,30	0,30
		Weite	0,20	0,20	0,30	0,30	0,35	0,35	0,35	0,40	0,40	0,45
	2	Länge	0,15	0,20	0,20	0,20	0,20	0,25	0,25	0,25	0,25	0,25
		Weite	0,20	0,25	0,25	0,30	0,30	0,30	0,30	0,35	0,35	0,35



Tabelle III

Messen des Wuchses der Kapseln von *Primula obconica* HANCE vom 25. Februar  
bis 6. April, 1917. Bestäubt am 21. Februar.

Datum der Messung			25./II	1./III	5./III	9./III	13./III	17./III	21./III	25./III	29./III	6./IV
Xenogamie (L × K)	1	Länge	0.15	0.20	0.20	0.25	0.25	0.30	0.30	0.30	0.35	0.35
		Weite	0.20	0.25	0.25	0.30	0.35	0.40	0.40	0.45	0.45	0.50
	2	Länge	0.25	0.25	0.25	0.30	0.30	0.30	0.35	0.35	0.35	0.35
		Weite	0.20	0.25	0.30	0.35	0.35	0.40	0.40	0.40	0.15	0.45
Xenogamie (K × L)	1	Länge	0.15	0.15	0.20	0.20	0.20	0.20	0.25	0.25	0.30	0.30
		Weite	0.20	0.20	0.25	0.25	0.25	0.30	0.30	0.35	0.35	0.40
	2	Länge	0.20	0.25	0.25	0.25	0.30	0.30	0.30	0.35	0.35	0.35
		Weite	0.25	0.30	0.30	0.35	0.35	0.40	0.40	0.45	0.45	0.45
Xenogamie (L × L)	1	Länge	0.15	0.15	0.15	0.15	0.20	0.20	—	—	—	—
		Weite	0.20	0.20	0.20	0.20	0.25	0.25	—	—	—	—
	2	Länge	0.15	0.15	0.20	0.20	0.20	—	—	—	—	—
		Weite	0.20	0.20	0.20	0.20	0.20	—	—	—	—	—
Xenogamie (K × K)	1	Länge	0.20	0.20	0.20	0.20	0.20	—	—	—	—	—
		Weite	0.25	0.25	0.25	0.25	0.25	—	—	—	—	—
	2	Länge	0.15	0.15	0.15	0.20	0.20	0.20	—	—	—	—
		Weite	0.20	0.20	0.20	0.25	0.25	0.25	—	—	—	—
Geitonogamie (L)	1	Länge	0.15	0.20	0.20	0.20	0.20	0.20	—	—	—	—
		Weite	0.20	0.25	0.25	0.25	0.25	0.25	—	—	—	—
	2	Länge	0.15	0.20	0.20	0.20	0.25	0.25	—	—	—	—
		Weite	0.20	0.25	0.25	0.25	0.30	0.30	—	—	—	—
Geitonogamie (K)	1	Länge	0.15	0.20	0.20	0.20	0.20	—	—	—	—	—
		Weite	0.20	0.25	0.25	0.25	0.25	—	—	—	—	—
	2	Länge	0.15	0.20	0.20	0.20	0.20	0.20	—	—	—	—
		Weite	0.20	0.25	0.25	0.25	0.25	0.25	—	—	—	—
Autogamie (L)	1	Länge	0.15	0.20	0.20	0.20	0.20	0.20	0.20	—	—	—
		Weite	0.20	0.25	0.25	0.25	0.25	0.30	0.30	—	—	—
	2	Länge	0.20	0.20	0.25	0.25	0.25	0.25	0.25	—	—	—
		Weite	0.25	0.25	0.25	0.25	0.30	0.30	0.30	—	—	—
Autogamie (K)	1	Länge	0.20	0.20	0.20	0.20	0.25	0.25	—	—	—	—
		Weite	0.20	0.25	0.25	0.25	0.30	0.30	—	—	—	—
	2	Länge	0.20	0.20	0.20	0.20	0.25	0.25	0.25	—	—	—
		Weite	0.25	0.25	0.25	0.25	0.30	0.30	0.30	—	—	—





Tabelle IV

Übersicht der im Text angegebenen tabellarischen Resultate mit  
Ausnahme desjenigen von *Triglochin hirta* Hook.

Species	Zahl der Exem- plare	Befruchtung		Anzahl befruchteter Blumen	Anzahl erzeugter Kapseln	Anzahl erzeugter Samen	Frucht- barkeit (%)	Durchschnitts- länge der Kapseln in cm	Durchschnitts- weite der Kapseln in cm	Durchschnitts- anzahl von Samen in der Kapsel	Durchschnitts- gewicht von Samen in g
<i>Primula sibirica</i> LINDL.	10	Xenogamie	L × K	15	13	487	83	0.93	0.83	37	0.00108
			K × L	27	21	812	77	0.83	0.73	42	0.00069
			L × L	36	30	658	83	0.71	0.74	21	0.00091
			K × K	50	40	1208	80	0.68	0.68	30	0.00106
		Geitonoga- mie	L	22	4	88	27	0.68	0.70	22	0.00110
			K	20	10	170	50	0.59	0.62	17	0.00089
<i>Primula obconica</i> HANCE.	10	Xenogamie	L × K	57	55	2806	94	0.38	0.49	51	0.00026
			K × L	63	50	2301	82	0.36	0.48	44	0.00028
			L × L	38	9	33	23	0.25	0.29	3	0.00001
			K × K	32	9	16	28	0.22	0.27	1	0.00003
		Geitonoga- mie	L	42	5	12	9	0.34	0.41	5	0.00004
			K	25	2	5	8	0.22	0.30	2	0.00004
		Autogamie	L	44	5	7	11	0.31	0.38	1	0.00003
			K	32	3	19	6	0.33	0.38	6	0.00003
		Xenogamie		521	475	13287	91	5.78	0.55	27	0.0027
				592	423	11570	84	5.67	0.55	27	0.0028
<i>Brassica cam- pestris</i> L. subsp. <i>chinensis</i> Max.	14	Geitonogamie		663	451	12047	68	5.52	0.53	26	0.0027
		Xenogamie		221	214	5244	97	4.96	0.59	24	0.0034
		Autogamie		275	223	4795	81	4.51	0.53	21	0.0033
<i>Brassica campe- stris</i> L. subsp. <i>chin- ensis</i> Max. var. <i>toona</i> Max.	14	Xenogamie		436	420	5603	96	3.18	0.64	13	0.0016
		Geitonogamie		387	300	3534	77	3.19	0.60	11	0.0020
		Autogamie		665	502	5346	74	3.00	0.62	10	0.0022
<i>Brassica campe- stris</i> L. subsp. <i>rapa</i> Hook f. et ANDS.	6	Xenogamie		170	161	2616	94	4.89	0.47	16	0.0025
		Geitonogamie		200	179	2943	89	4.52	0.42	15	0.0012
		Autogamie		236	182	2812	88	4.70	0.45	16	0.0020
<i>Hyoscyamus orientalis</i> L.	10	Xenogamie		27	24	212	88	1.81	1.54	13	0.0149
		Geitonogamie		24	13	77	54	1.70	1.37	5	0.0174
		Autogamie		25	13	83	52	1.67	1.44	6	0.0208
<i>Eresia Leicht- lini</i> Klatt.	20	Xenogamie		64	24	321	37	1.27	1.08	13	0.0093
		Geitonogamie		60	0	0	—	—	—	—	—
		Autogamie		62	6	12	9	0.93	0.78	2	0.0160
<i>Trifolium aureum</i> PARR.	24	Xenogamie		78	24	396	30	1.00	0.61	15	0.0042
		Geitonogamie		57	19	69	33	0.74	0.50	3	0.0049
		Autogamie		86	17	52	19	0.73	0.49	3	0.0051



Y. Emoto,

Über die relative Wirksamkeit von Kreuz- und Selbstbefruchtung  
bei einigen Pflanzen.

Tafel I.

## Erklärung der Tafel I.

Fig. 1. Vergleich der Fruchtbarkeit von *Brassica campestris* L. subsp. *chinensis* MAK.

Fig. 2. Vergleich der Fruchtbarkeit von *Brassica campestris* L. subsp. *chinensis* MAK. var. *Toona* MAK.

Fig. 3. Vergleich der Kapseln von *Tritonia aurea* PAPP.

Fig. 1.

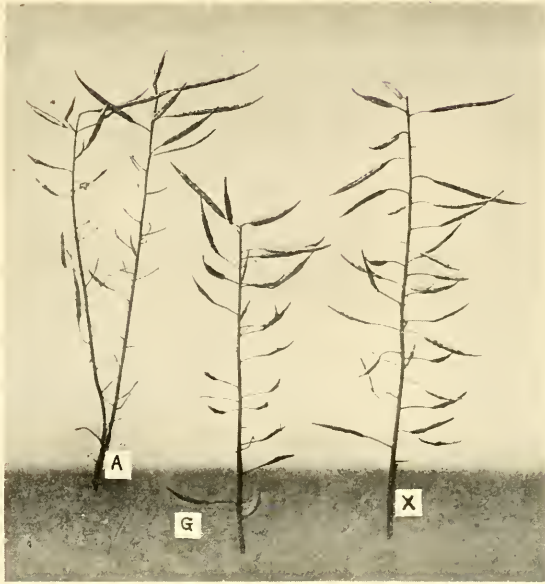


Fig. 2.



Fig. 3.



Scale:







Y. Emoto,

Über die relative Wirksamkeit von Kreuz- und Selbstbefruchtung  
bei einigen Pflanzen.

Tafel II.

## Erklärung der Tafel II.

Fig. 1. Vergleich der Kapseln von *Hyacinthus orientalis* L.

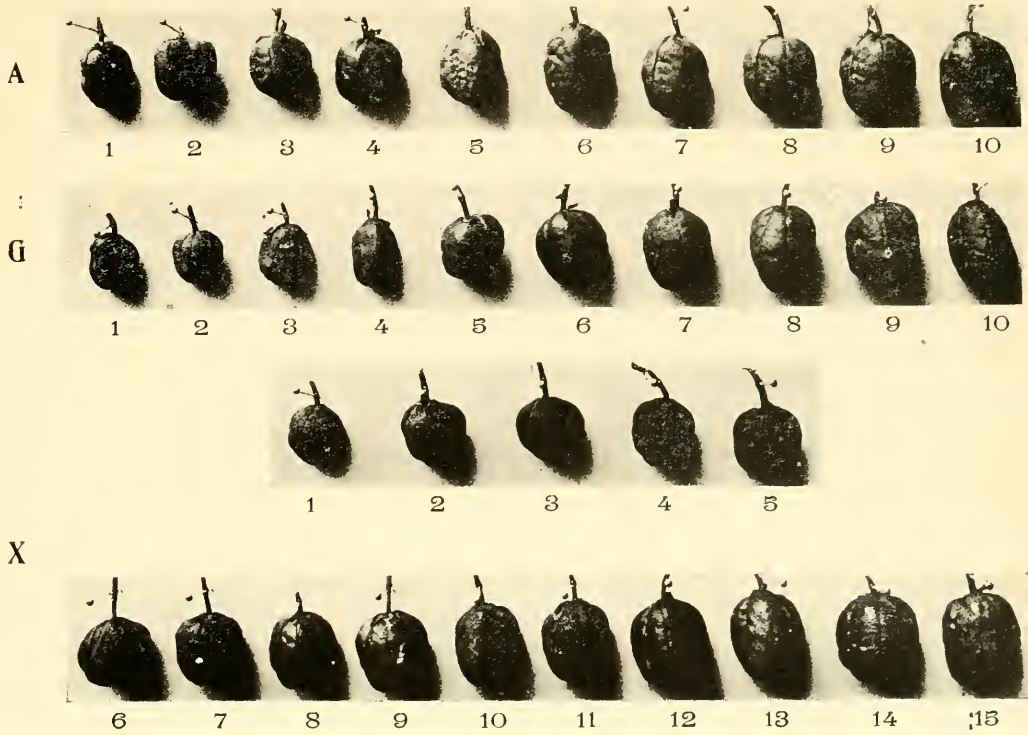
fig. 2. Vergleich der Kapseln von *Freesia Leichtlini* KLATT.

X . . . . . Xenogamie.

G . . . . . Geitonogamie.

A . . . . . Autogamie.

Fig. 1.



Scale:

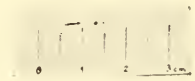
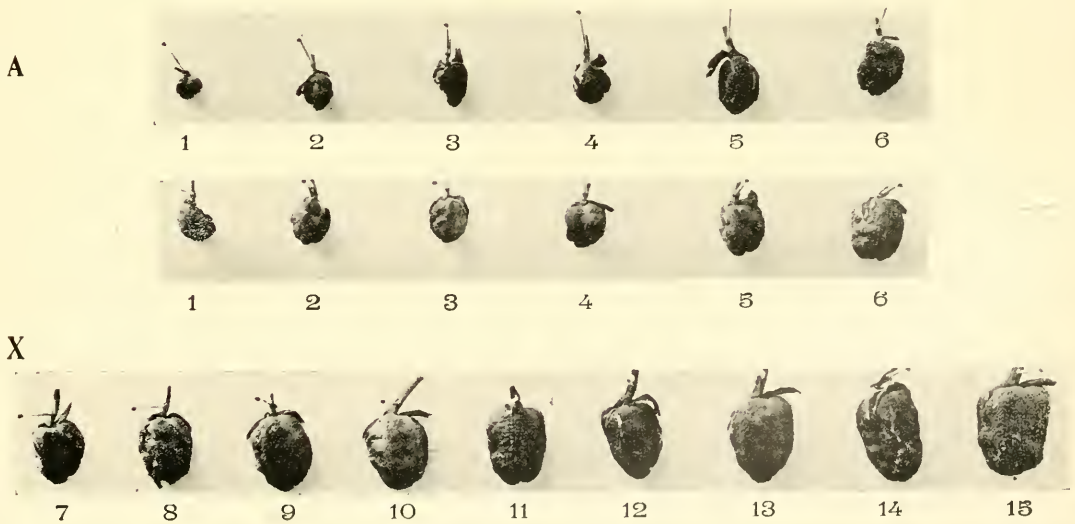


Fig. 2.



Scale:





**A Contribution to the Knowledge of the Cassiterite  
Veins of Pneumato-Hydatogenetic or Hydro-  
thermal Origin. A Study of the Copper-Tin  
Veins of the Akénobé District in the  
Province of Tajima, Japan.**

By

**Takeo KATŌ**, *Rigakushi*.

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*With 7 Plates and 11 Text-figures.*

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**I. INTRODUCTION.**

In the course of his investigation of the veins of the Akénobé district, the present writer found many interesting facts concerning the genesis of tin veins in general. Particularly, the writer's attention was called to the presence of chalcedony<sup>1)</sup> in the principal vein of this district as an important vein-stuff in association with cassiterite, and to the alterations of the wall-rocks characteristic of hydrothermal processes. Consequently, he was led to the conclusion that the copper-tin veins of this district were formed chiefly under pneumato-hydatogenetic or hydrothermal conditions. These are the same conditions under which the tin veins of the Suzuyama (or Taniyama) mine were formed.<sup>2)</sup> It is highly probable that similar

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1) T. Katō, "The ring-ore from the Akénobé mine, Province of Tajima, Japan," Journ. Geol. Soc. Tôkyô, Vol. XXIV., 1917, pp. 35-41.

2) T. Katō, "On the pneumato-hydatogenetic or hydrothermal formation of some cassiterite veins. A microscopic study of the tin veins of the Suzuyama mine, Province of Satsuma, Japan," Journ. Geol. Soc. Tôkyô, Vol. XXIII., 1916, pp. 145-164.

tin veins are abundant throughout the world, and they are commonly found in sedimentary rocks more or less distant from igneous rocks or ore-bringers.<sup>1)</sup>



Fig. 1. View of the village of Akénobé, as seen from south.

The Akénobé mining district lies on the upper course of the Akénobé-gawa, a tributary of the Hirotani River, which joins the Maruyama River near the railway station of Yabu on the San'in line. The village of Akénobé (Figs. 1, 4) is situated at the center of the district, about 25 kilometers southwest of the station of Yabu. It is also accessible from the station of Nii on the Bantan line, about 18 km. east from the village. This district has precipitous mountain ranges on three sides, viz., south, east and west, while the Akénobé River runs towards the north and a highway leads from Akénobé to the town of Ôya and beyond along the valley to Yôka and Yabu. It occupies geographically a very disadvantageous position in Eastern Chûgoku.

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1) Refer:—H. G. Ferguson and A. M. Bateman, "Geologic features of tin deposits," *Econ. Geol.*, Vol. VII, 1912, pp. 209-262; J. T. Singewald, "Some genetic relations of tin deposits," *Econ. Geol.*, Vol. VII, 1912, pp. 263-279; W. H. Twelvetrees and L. K. Ward, *Bull. 8*, Department of Mines, Tasmania, 1910.



This district was thoroughly studied and mapped about thirty years ago by T. Kochibe<sup>1)</sup>, whose report on its geology and ore deposits is of high value even at present, but many new data and facts since brought to light by progressive mining explorations necessitate a more detailed study, which lead to conclusions somewhat different from those reached by the above mentioned author.

Before proceeding further, I must here fulfill the pleasant duty of acknowledging my deep indebtedness to the munificence of Tokujirô Fujita Esq. of Osakâ, whose liberal offer of all the necessary expenses has enabled me to publish this paper in its present form.

## II. TOPOGRAPHY.

The Akénobé mining district forms a part of the mountainous region of Eastern Chûgoku, consisting of precipitous peaks and ranges of about 1000 meters (Fig. 2). The western and central parts of Chûgoku are very remarkable in their physiographic features, inasmuch as they form an elevated peneplain sculptured deeply by rejuvenated rivers (Fig. 3).<sup>2)3)</sup> But in the district now in question, the topography is somewhat different. It is in ripe maturity. Peaks are generally more precipitous and higher in this district than in the western and central parts of Chûgoku. The prominent peaks in the area under consideration are Suruga-miné (1053 m.), Takaiwa-miné (1054 m.), Shiroya-miné (930 m.) on the eastern side of the Akénobé valley; Sora-yama (977 m.) and Ryôken-zan (786 m.) on the south; and Sajimi-yama (960 m.) and others on the west. On observing the general topography from the summit

1) T. Kochibe. "Geology and ore deposits of the Ikuno mine," 1890 (in Japanese).

2) B. Kotô, "The physiographic type of Chûgoku," Report, Earthq. Invest. Committee, No. 63, pp. 1-15.

3) T. Katô, "The ore deposits in the environs of Hanano-yama, near the town of Ôda, Prov. Nagato, Japan," Journ. Meiji Coll. Techn., Vol. I, No. 1, 1916.



Fig. 2. View of the precipitous mountains and deep valleys in the Akénobé district, as seen from the summit of Suruga miné.  
Compare with Fig. 3. a = Akénobé valley.

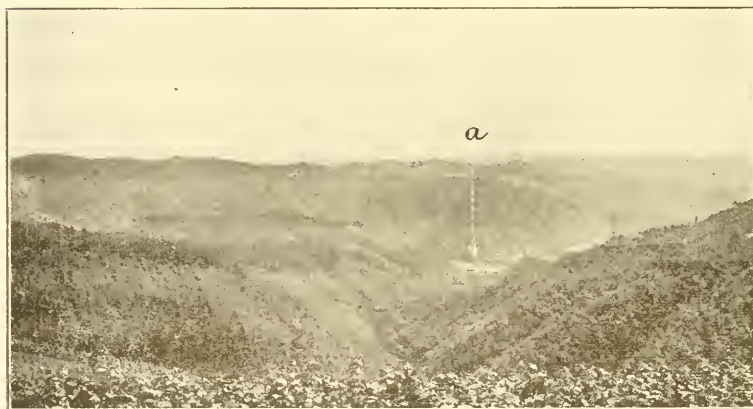


Fig. 3. View of the middle course of the Yoshii-gawa valley, from a height near the Yanabara mine in the province of Mimasaka.  
Note the elevated peneplain dissected by rejuvenated rivers, the characteristic topography of the central part of Chûgoku.  
a = Yoshii River.

of a high peak in this district, however, we can find here and there rather indistinct relics of the original plateau or elevated peneplain, though the average height is much greater than in the other parts of Chûgoku. It is certain, therefore, that this district

underwent peneplanation during the Mesozoic continental period of Chûgoku. During the latest upwarping period, i.e., the Tertiary age, this district was elevated more than 1000 meters, while the upheaval of the western and central parts of Chûgoku has been generally from 400 to 500 meters. Thus the elevated peneplain formed at this period had a higher surface in this district, and, consequently, the rejuvenescence of rivers was more conspicuous and erosion more active here than in the other districts. For these reasons, the district in question is full of precipitous mountains, while the other parts of Chûgoku still remain an elevated peneplain deeply sculptured by rejuvenated rivers. It is proved by field observations, however, that faults and other tectonic disturbances have also played not unimportant parts in the formation of the present physiographic features of this district.

### III. GENERAL GEOLOGY.

In its geological structure Eastern Chûgoku is very complicated, being composed of sedimentary complexes of diverse ages, intricately faulted and folded, and intruded by various igneous rocks. A glance on the general geological map<sup>1)</sup> of this region shows this clearly. The Akénobé mining district, being only a small part of this complicated region, encloses comparatively few rock varieties, consequently the intricate major structure cannot be revealed by the field study of such a limited area as the district in question. Considered petrologically, however, this district affords many instructive data, especially concerning the alterations of rocks by hydrothermal solutions, to the action of which the formation of most veins of this district is due.

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1) Ikuno Sheet, in scale 1:200,000, published by Imp. Geol. Survey of Japan.

This district consists of sedimentary rocks of Paleozoic and Mesozoic ages, together with igneous rocks such as diorites, porphyrites, andesites, liparitic rocks and others.

#### (A) The Paleozoic Formation.

The Paleozoic formation<sup>1)</sup> developed in this district consists chiefly of slaty rocks with subordinate quartzite, sandy rocks, and schalstein in association with diabase. The complex is highly disturbed, but in general the strata strike N. 40°–50° E. and dip towards N.W. at an angle of 30°–50°.

*Clay Slate.* This forms the most important country rock of the copper-tin veins of this district. Fresh slate, not influenced by mineralizing solutions, is commonly rich in carbonaceous matter and black in colour, hard and compact, and shows rather indistinct cleavage. Under the microscope, the black slate is seen to consist largely of an exceedingly fine textured base or paste, very difficult to resolve, in which fine grains of quartz and feldspar, flakes of chlorite, etc. are imbedded. Carbonaceous matter is abundantly scattered in dusty particles or in minute specks. Sometimes it is silicified to a considerable extent and is penetrated by veinlets consisting of quartz and epidote. This rock is well exposed in the environs of the Shōtoku adit, as well as near the western entrance of the Myōjin tunnel, and in several other places.

The slate is frequently altered to dark green rocks, particularly in the environs of the Daisen vein. At first sight the altered slate is scarcely recognizable, because the slaty cleavage has usually disappeared, and the rock has lost its splintery nature and become rather massive. The faint appearance of bedding in places is the only remaining field evidence of the original character in some of

---

1) So-called "Chichiba System."

the outcrops. The alteration of the slate into green rocks is most probably due to the action of the mineralizing solutions with which the copper-tin veins are genetically connected, thus affording very instructive data as to the genesis of the veins in question. It will, therefore, be fully discussed in a subsequent chapter.

The slate is sometimes metamorphosed to phyllitic rocks by dynamic processes. These are particularly well developed in the environs of the Minamidani mine. All gradations, from carbonaceous and green slates to highly schistose rocks, are observed. The prevailing rocks are light grayish or light bluish green phyllites, showing a characteristic silky luster, with well developed cleavage structure. As can be observed under the microscope, abundant felty sericite is developed and in places a fair amount of flaky biotite (Pl. II., Fig. 1). Both micas are characteristically arranged along the cleavage planes. The rocks appear to have undergone recrystallization and granulation to a considerable extent, abundant fine grains of feldspar and quartz parallel to the cleavage plane being visible. Veinlets traversing the phyllites are common. Some of the veinlets consist of granular quartz containing a small quantity of epidote grains, while others are composed essentially of yellowish coloured, pleochroic epidote in granular aggregation, in association with a small amount of quartz grains.

A bed of *calcareous biotite-epidote schist* is exposed near the Minamidani mine, which is probably a metamorphosed limestone or calcareous shale. It is intercalated between the phyllites. It is highly schistose in structure and the development both of flakes of biotite and grains and crystals of epidote along the plane of schistosity is very conspicuous. Microscopic crystals of garnet are also developed. As a whole, recrystallized and granulated calcite



mingled with a small quantity of quartz grains makes up the main bulk of this schistose rock.

*Quartzite.* This occurs occasionally in the form of a thick intercalation in the slate complex, forming cliffy walls along its strike, as on the mountain-slope northeast of the Daisen mine (Figs. 4, 5) and in several other places. It is hard and compact, white or grayish white in colour, often stained with limonitic substance and manganese oxide along the cracks and irregular joints in which it is very rich. As can be seen under the microscope, it is composed of inequidimensional grains of quartz, larger grains being scattered like phenocrysts through an aggregate of minute grains (Pl. II., Fig. 6). It is evident that the rock has undergone intense granulation, because the larger grains often show undulatory extinction and their margins grade into cataclastized fine grains. The rock is contaminated with microscopic flecks and stringers of limonite, and is intricately traversed by fine veinlets consisting of quartz grains.



Fig. 4. View of the village of Akénobé and the Daisen mine, seen from north.

d=Daisen mine. m=Meisei mine. Q=quartzite cliff.



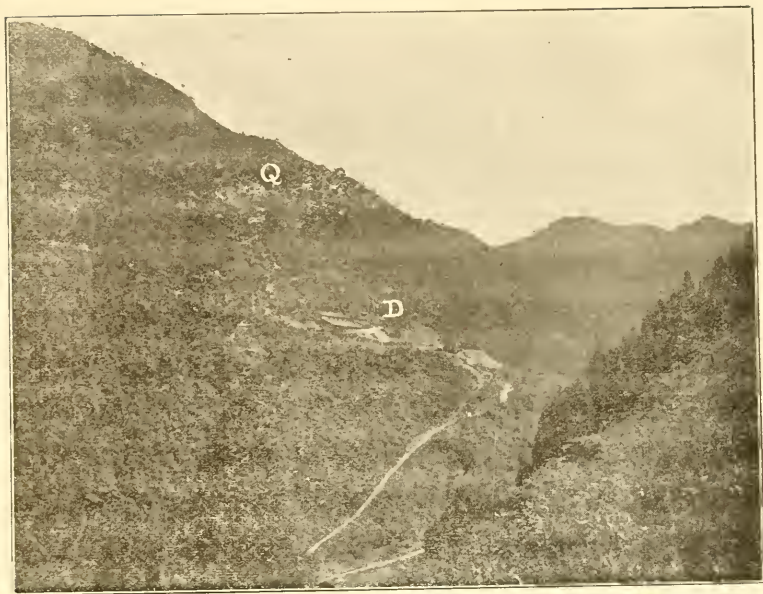


Fig. 5. Nearer view of the Daisen mine (D). Q=Quartzite cliff.

*Schalstein and Diabase.* Specimens of an aphanitic dark green rock were collected along the road near the Daidô mine. In the field this was taken for a metamorphosed slate, because it was intercalated between highly metamorphosed, more or less epidotized, dark green slates, but after a microscopic examination, it was found to be a diabasic rock, whose original ferromagnesian mineral, augite, is entirely uralitized—uralite diabase. This rock is evidently a member of the Paleozoic formation representing a schalstein horizon, as is usual in the Chichibu System.

Under the microscope, the rock is found to be composed chiefly of amphibole and decomposed plagioclase (Pl. II., Fig. 5); both constituents are 0.3–0.5 mm. in length and confusedly aggregated. Sometimes, however, ophitic and intersertal structures are recognized, the interstices between the lath-shaped plagioclase crystals usually being filled with uralitized augite. Plagioclase is as a rule badly kaolinized and appears cloudy, and the borders are

less defined. Usually the uralite is characteristically fibrous in structure and strongly pleochroic, from bright green to yellow. The original form of augite is usually obliterated and has become flaky and bent, although occasionally the transition of the prismatic cleavage from augite to hornblende is observed in basal sections. Iron ores, chiefly of secondary formation, are scattered in fair quantities through the rock. Abundant chlorite, in clusters of minute granules and in large flakes, is developed in some parts.

The rock is occasionally cut by veinlets consisting of xenomorphic grains of fresh albite mingled with chlorite flakes and epidote grains. The epidote is almost colourless in thin section and is characterized by bright speckled interference colours.

*Radiolarian Slate.* A bed of brownish red slate containing *Radiolaria* remains has been found in the Minamidani area, where the rocks are generally more or less metamorphosed. This is also a characteristic member of the Paleozoic formation of Japan.

### (B) The Mesozoic Formation.

In the environs of the Daijukô mine, the country rock consists of black slates interstratified with gray slate, sandstone and conglomerate beds. A lenticular limestone is also found at a spot in the black slate terrane. Thus it differs conspicuously in character from the green slate complex developed in the environs of the Daisen mine.

The black slate complex now under consideration has a general strike of N.  $20^{\circ}$ – $40^{\circ}$  E. and dips towards N. W. at an angle of  $20^{\circ}$ – $30^{\circ}$ . Thus, the strike and dip of this complex differ very slightly from those of the green slate complex. In this district the two complexes are bounded by a great fault as shown in the annexed geological map (Pl. I.).

As can be observed by a general geological reconnaissance of the Akénobé district, the black slate complex appears to occupy a higher position than the green slate complex, and, moreover, the former is commonly far less metamorphosed and disturbed than the latter. The conglomerate bed, a member of the black slate complex, contains gravels of diverse character, of which flinty hornstone or chert plays an important part; the flinty hornstone is a characteristic member of the Paleozoic formation of Japan. Thus, although the exact age of the black slate complex remains undetermined, because no leading fossil has been found even in the limestone bed intercalated in it, it is evidently younger than the green slate complex and probably of the Mesozoic age.

The predominant rock of the Mesozoic formation in question is black slate. It is highly carbonaceous, and shows distinct cleavage almost parallel to bedding planes. Adjacent to the veins it is frequently more or less silicified or admixed with chlorite, and resembles in some respects the wall-rock of the Daisen and other veins in the Paleozoic terrane. In places, it is intricately traversed by quartz veinlets.

Gray-coloured shale, poor in carbonaceous matter, occurs frequently as a thick bed intercalated between the black slates. Sandy shales, representing all gradations between shale and sandstone, are likewise common associates.

Sandstone is also intercalated between slates, sometimes as a thick bed. When fresh, it is gray in colour and compact in texture, but when altered, particularly by the mineralizing solutions, it has become more or less green in colour and is easily mistaken for a diabase.

A conglomerate bed is exposed on the upper course of the valley along which the Daijukô mine lies. The same bed is

extensively developed in this area and is exposed on the road side near the Fudono Pass leading from Fudono to Akénobé. It is several meters thick and contains large and small pebbles of flinty hornstone, clay slate, altered porphyrite and other rocks cemented firmly by a sandy matter. The amount and size of the pebbles vary even in different portions of the same bed, the rock frequently grading into sandstone within a small distance.

A limestone bed is found near the Fudono Pass, a little distant from the road, intercalated between the gray shales and resting directly on the conglomerate bed, just described. It is lenticular in form, with a thickness of several decameters. It is light gray in colour and very compact in texture. No characteristic fossil has yet been found macroscopically as well as microscopically, except sporadic imperfect remains of crinoid stems. The limestone is of very rare occurrence in the so-called Mesozoic formation of this district, and represents local accumulations of calcareous mud in the Mesozoic sea.

### (C) Dioritic Rocks.

Dioritic rocks are very extensively exposed in this district. These are all intrusive into the Paleozoic and Mesozoic sedimentaries either in the shape of great masses or in small offshoots. The contact effects are not conspicuous, though the diopsidization of the slate complex, which is observed here and there near the contacts with the dioritic rocks, is obviously related to the intrusion of the igneous rocks under consideration. Other effects, if present, have been rendered obscure by later hydrothermal and dynamic metamorphisms. The diopsidization will be fully treated in a subsequent chapter.

Although all the dioritic rocks in this district belong to the

same period of irruption, they show sometimes conspicuous differences in character even in different portions of the same mass. The following are the chief types:—

*Gabbroid Diorite.* Near the entrance of the Sekiei 5th adit, a small mass of gabbroid rock is exposed. It is a part of the large dyke-shaped mass which is met with in the main cross-cut between the Nihonmatsu and Sekiei veins, and continues to the outcrop of a lighter coloured dioritic rock observed on the slope between the Daisen main adit and the Sekiei 5th adit.

The rock is usually more or less decomposed. It is medium-grained holocrystalline rock, consisting of white feldspathic and dark green ferromagnesian ingredients, sometimes showing indistinct parallel arrangement of the constituent-minerals due to dynamic processes.

Under the microscope, the rock is composed chiefly of plagioclase, hornblende and a small quantity of malacolite (Pl. IV., Fig. 2). The plagioclase is commonly xenomorphic, while the ferromagnesian minerals are idiomorphic or hypidiomorphic. The plagioclase is usually either altered to kaolin, appearing turbid, or changed to dense aggregates of clear transparent flakes and fibers of sericite; sometimes it is altered to saussurite or an aggregate of minute grains and prisms of clinozoisite-epidote minerals. The hornblende forms the predominant constituent of the rock, and occurs in aggregates of hypidiomorphic grains and idiomorphic prismatic crystals, often bent and torn by dynamic processes (Pl. IV., Fig. 5). It is very light coloured but distinctly pleochroic,  $\parallel$   $\epsilon$  light green,  $\perp$   $\epsilon$  light yellow to almost colourless. The extinction angle is very small,  $c:\epsilon = \text{ca. } 15^\circ$ . The plagioclase encloses the crystals and grains of hornblende, and fills up the interstices between the latter. A small quantity of colourless malacolite in



hypidiomorphic and idiomorphic crystals is found in association with hornblende. Sporadic apatite needles are present as a primary accessory mineral. Insect-egg-like titanite, probably an alteration-product of ilmenite, is widely scattered through the rock. The ferromagnesian minerals are sometimes altered to fibrous chlorite showing an anomalous deep blue interference colour. Moreover, veinlets of chlorite occasionally cut the rock.

Similar rocks are found near the Higashiyama vein, as well as adjacent to the Meisei vein, and in other places.

*Altered Diorite.* The dyke or elongated boss exposed between the Daisen and Sekiei veins, together with the mass exposed along the road leading from Akénobé to Fudono, belongs to this category.

These rocks are commonly decomposed to dark or light green compact rocks, often showing no granular structure macroscopically. Sometimes they are highly silicified and very hard. In places, they resemble in many respects the green slate which is developed very extensively in this district. When they are found in the green slate terrane, their presence can scarcely be detected without the aid of a microscope.

Under the microscope, plagioclase is altered to kaolin, or more frequently to saussurite or an aggregate of clinozoisite and epidote. Only sporadically is the form of the feldspar preserved, and the characteristic twin-lamellae are observed between crossed nicols. Hornblende is altered to chlorite and its original crystal form is usually obliterated, although very rarely the mineral is found in the form of bent and torn fragments scattered irregularly through the rock. Chlorite often forms veinlets and streaks, occurring either along the boundaries between crystals and grains of the altered feldspar, or cutting them. In the silicified diorite, quartz occurs in



intricately intersecting veinlets and in irregular grains filling the interstices between the altered feldspar and other constituents. The quartz shows often undulatory extinction and is cut by stringers of clinozoisite squeezed out from the surrounding saussurite. These facts suggest that the rock has undergone conspicuous dynamic action after the infiltration of quartz.

*Schistose Diorite.* The diorite in this district shows in places a remarkable schistose structure. The schistose diorite is extensively developed on the ridge between Akénobé and Mikobata, particularly in the environs of the abandoned pits of the Kasei mine. It is evidently a facies of the main diorite from which innumerable offshoots are led out.

As can be observed under the microscope, prismatic crystals of hornblende with no terminal faces are arranged in somewhat parallel orientation, the feldspathic constituents filling the interstices between the hornblende crystals and also forming colourless bands and streaks in alternation with the layers composed of aggregates of prismatic hornblende (Pl. IV., Fig. 6). The feldspar has undergone intense granulation, and is changed to aggregates of fine grains admixed with fair quantities of fibers and flakes of secondary sericite, in association with prismatic crystals and grains of clinozoisite and epidote. The hornblende is light coloured and distinctly pleochroic, light greenish yellow to light green. It shows characteristically corroded forms, embayed by feldspar (Pl. IV., Fig. 6). Pyrrhotite in small specks is widely scattered through the rock. The rock is often cut by quartz veinlets containing a small quantity of flaky muscovite.

*Diorite Mylonite.* The diorite in this district, especially that forming the main stock which is exposed on the ridge between Akénobé and Mikobata, has undergone intense dynamic processes,

resulting in a schistose structure in the rock as described above. The mylonite, now under consideration, is one of the most characteristic products of the dynamic processes.

In the course of driving the Myōjin tunnel which leads from the village of Akénobé to Mikobata, it was found that a more or less altered black slate (Paleozoic) constituted the west entrance of the tunnel and was continuous for about 30 meters, giving place to dioritic rocks, which form the greater part of the mountain mass through which the tunnel was driven. The diorite collected near the contact with the slate is light green and mottled in colour, usually more or less greasy to the touch, and resembling in some respects talcose or serpentinous rocks. Sometimes macroscopic distinction between this rock and the altered green slate showing indistinct bedding planes is very difficult.

Under the microscope, this rock is seen to have been strongly mylonitized. It is composed of irregular-shaped grains of plagioclase and very pale green hornblende. The plagioclase belongs to the oligoclase-andesine group and is characterized by very narrow polysynthetic twin-lamellae, and often shows undulatory extinction. It is usually mylonitized to a considerable extent. The margins of the larger grains are crushed to fine grains (Pl. IV., Fig. 1), and, moreover, fissures and cracks through the larger grains are filled with mylonitized grains. In places, the feldspar is entirely crushed to very fine grains. The hornblende has also undergone mylonitization, though not so intensely as in the feldspar. It is often torn and bent, and in places crushed into minute grains and fibrous flakes commingled with grains of feldspar. The hornblende is occasionally altered to chlorite by later decomposition. Quartz is present in varying quantities, always filling up the interstices between the larger grains of feldspar and hornblende, and also the

minute fissures in the rock. It is clearly of secondary infiltration as the lack of a cataclastic structure suggests.

*Akenobeite*, a leucocrate differentiated from the diorite magma. At Higashiyama, about 500 meters northeast of the village of Akénobé, a leucocratic rock in the form of a small boss, or apophysis, is exposed in close association with diorite. It lies adjacent to the outcrop of the abandoned copper-tin vein of Higashiyama. In the field it is clear that it represents a leucocrate differentiated from the diorite magma.

The rock in question is medium-grained in texture, the chief component, feldspar, often measuring 3 mm. or more in length. Usually being very poor in ferromagnesian minerals, it is pure white or very light coloured.

Under the microscope, it shows a unique structure. It is composed essentially of thick tabular idiomorphic and hypidiomorphic crystals of feldspar in confused aggregation, the interstices between them being filled with an aggregate of fine grains of quartz (Pl. IV., Figs. 3, 4). Two kinds of feldspar are distinguished, namely, oligoclase and orthoclase. The characteristic narrow polysynthetic twin-lamellae easily distinguish the oligoclase from the orthoclase, which occurs usually in simple crystals or in Karlsbad twins. The plagioclase always exceeds the orthoclase. They are all characterized by the indices of refraction, being lower than the adjoining quartz, and are more or less kaolinized and turbid. The quartz filling the interstices between the feldspars is rather small in amount. Sometimes the feldspars are more or less corroded along their margins, and invaded along the cracks by the quartz. The quartz is easily distinguished from the feldspars by its freshness and positive uniaxial character. Femic constituents play a very subordinate part in this rock. Biotite,

characterized by its perfect cleavage and strong pleochroism, wine yellow to dark green, occurs in minute flakes enclosed in feldspars. Sometimes it occurs in hypidiomorphic flakes attached to the well-defined borders of the feldspars, showing its subsequent crystallization. Minute flakes of chlorite, evidently a decomposition-product of biotite, is sparingly scattered through the rock. A small quantity of secondary epidote, very slightly pleochroic, yellow to colourless, and characterized by speckled interference colours, is present in the form of streaky aggregates along the cracks of feldspars, or in irregular patches replacing the same minerals, or in flakes overlapping quartz grains in the cementing matter.

The leucocrate, here considered, shows in places a typical aplitic structure, being fine-grained, rather equigranular, and consisting of rounded grains of quartz and hypidiomorphic and xenomorphic feldspars (both oligoclase and orthoclase) and a fair quantity of green biotite in minute flakes. A gradual transition from one structure to the other may always be observed.

To this peculiar leucocrate, corresponding in mineral-composition to quartz-monzonite-pegmatite or aplite, the writer gives the name of 'akenobeite.' It is the only acid granular rock found in this vein district, and it is particularly noteworthy that it is a differentiation-product of the diorite magma.

All the dioritic rocks in this district, hitherto described, are derived from the same source, and erupted during the same period, probably a late Mesozoic age. The main intrusive mass forms the southern and eastern parts of the Akénobé district, while the offshoots are found here and there in large dykes and bossy masses throughout the vein district. Some of the offshoots are evidently of later intrusion than the main mass, having been derived from the unconsolidated portions of the same magma-basin. It is worthy

of special attention that the main stock has undergone intense dynamic processes, resulting, in places, in schistose diorite, mylonite, etc., while the offshoots show frequently only a slight sign of dynamo-metamorphism. The offshoots are often altered to greenstones, particularly near the veins; this alteration is believed to be due to the hydrothermal processes.

### (D) Dyke Rocks.

Numerous small dykes, ranging in thickness from a fraction of one meter to several meters, are found in the vein district now under consideration. Those dykes are often decomposed to gray or whitish rocks with an earthy texture. As can be discerned on microscopic study, they are petrologically of diverse characters, the important types being andesites, felsites, porphyries, porphyrites, and diabases.

*Hornblende-Hypersthene Andesite.* In the abandoned adit of Ishikané, in the Daijukô area, where the eastern continuation of the Daikoku vein was worked, two dykes are found across the vein. They strike N. E. and dip very steeply towards N. W. The one nearer to the entrance of the adit has a thickness of 3 meters or more, the other of only a fraction of one meter. The rock is dark coloured and compact. When decomposed, phenocrysts of feldspar and hornblende are clearly recognizable with the unaided eye, the hornblende occasionally attaining a length of 5 mm. or more, though commonly much shorter.

Under the microscope, the groundmass shows a trachytic structure consisting of innumerable plagioclase laths in parallel or fluidal arrangement, mingled with abundant long prismatic microlites of rhombic pyroxene and fine crystals of magnetite. No glass-base is recognizable; it has probably been devitrified into indistinct



double-refracting minerals now admixed with the groundmass. In the groundmass, a small quantity of biotite occurs in irregular microscopic flakes sometimes overlapping the microlites of feldspar and pyroxene. It is characterized by strong pleochroism, perfect cleavage and a nearly uniaxial interference figure under the conoscope.

As phenocrysts occur plagioclase, hornblende and hypersthene. The plagioclase occurs in tabular idiomorphic crystals often attaining a length of 3 mm. It shows broad polysynthetic twin-lamellae. From indices of refraction and extinction angles, it is identified as labradorite. The hornblende is variable in amount and size even in different portions of the same dyke. It ranges from a microscopic size to several millimeters in length, and commonly occurs in well-defined crystals, showing distinct pleochroism, brown to light brown, and small extinction angle,  $c : \epsilon = 20^\circ$ . The hypersthene occurs in well-defined prismatic crystals characterized by the prismatic cleavage, transverse cracks and straight extinction, and shows distinct pleochroism,  $\parallel c$  pale green and  $\perp c$  light brownish yellow.

*Two-Pyroxene Andesite.* This occurs in small dykes, with a thickness varying from a fraction of a meter to 1 meter or more, in the Daisen area. One of this type is found near the entrance of the Kisei main adit, the southern continuation of the Daisen adit, striking N.-S., while another one is found a few hundred meters distant from the same entrance, running N. W. to S. E. obliquely across the Daisen vein (Pl. I.).

The rock is much decomposed and shows an earthy, compact texture with a light grayish colour. Abundant phenocrysts of feldspar with a length up to 1 mm. are visible. Long prismatic



crystals of hypersthene, usually less than 2 mm. in length, are sporadically found.

Under the microscope, the groundmass shows a hyalopilitic structure consisting of very minute feldspar laths, often in fluidal arrangement, and a devitrified glass-base mixed with abundant minute specks of calcite, mostly representing a decomposition-product of ferromagnesian minerals (Pl. III., Fig. 4). In fresh specimens a brown glass-base is present, cementing the feldspar laths and contaminated with minute grains of diopsidic augite. Minute crystals and grains of magnetite are scattered through the groundmass. Some ilmenite is evidently present as the presence of leucoxene, developed along the border of a few grains of black opaque iron ore, suggests.

Porphyritic plagioclase is always characterized by polysynthetic twinning and is tabular in habit. Its refraction is far higher than that of Canada balsam. The maximum symmetrical extinction (ca.  $35^{\circ}$ ) shows that it belongs evidently to the soda-calcic group, i.e., the labradorite-bytownite series. While the plagioclase phenocrysts are very abundant, ferromagnesian minerals are very sparse. Only sporadically are hypersthene crystals found with the naked eye. In addition, diopsidic augite, in small prismatic crystals, is sparingly distributed in fresh specimens. This rock, then, may be classed as two-pyroxene andesite very poor in ferromagnesian minerals.

*Garnetiferous Felsite-Porphry.* A light-coloured, garnetiferous igneous rock in the form of a dyke is exposed at the stream bottom near the meeting point of the Fudono road and the Mikobata road at the village of Akénobé. It is about 3 meters thick and strikes N. E. A similar garnetiferous dyke was discovered in the underground working in the Ebisu adit in the

Daijukô area. It strikes almost parallel to the vein, i. e., E. to W., and runs along the walls of the vein, cutting it here and there.

The rock is exceedingly altered and bleached. It is white to light greenish white in colour, compact in texture, and contains abundant white phenocrysts of feldspar with a length up to 5 mm. or more. No ferromagnesian minerals are recognizable. Most characteristic is the presence of a fair amount of porphyritic deep red garnet.

Under the microscope, the groundmass shows a microscopic granular structure consisting of fine xenomorphic grains of quartz and feldspar admixed with fair quantities of felty fibers of sericite and specks of calcite (Pl. III., Fig. 3). No ferromagnesian minerals are found in the groundmass; they have been decomposed and have disappeared. Sericite is probably an alteration-product of feldspar, and calcite represents the relics of altered ferromagnesian minerals.

The most important phenocryst is feldspar, ranging from a microscopic size to several millimeters in length. It is abundantly scattered through the groundmass. It is always entirely altered to kaolin which consists of weakly double-refracting powdery grains and gives rise to a turbid appearance. Calcite in irregular specks is also developed in altered feldspar, mingled with kaolin. Whether the feldspar belongs to orthoclase or plagioclase is not determinable, as it is entirely altered. Both kinds have probably been present. That the plagioclase has been present is indicated by the occasional presence of an altered feldspar showing a zonal structure made up of calcite and kaolin layers. Neither ferromagnesian minerals nor their decomposition-products retaining the original forms are recognized as phenocrysts. Irregular flecks

of calcite, sometimes admixed with cryptocrystalline hydroxide of iron, are scattered through the rock. The garnet is a very characteristic component and is sometimes abundantly scattered through the rock. It varies from a microscopic size to 3 mm., rarely up to 5 mm., in diameter, and is well crystallized in 202. or 202,  $\infty$  0. It is isotropic and irregularly cracked, and flesh-coloured in thin section. Inclusions of apatite needles, often attaining a length of 1 mm., are very common in garnet. The apatite is found also in the groundmass.

*Felsite.* A dull-lustered, compact and lithoiditic, white or gray-coloured rock is exposed, as a dyke through the green slates, along the road-cutting between the Meisei and Daidô mines, on the western side of the Akénobé River. It is about 3 meters thick, and strikes N. 20° E. and dips toward N. W. at an angle of 80°.

Under the microscope, it shows a microgranular structure consisting of xenomorphic grains of quartz and feldspar. While quartz remains fresh, feldspar is altered to kaolin admixed with more or less sericite in fibers and scales. No ferromagnesian minerals are recognizable, but here and there are scattered clusters of grains of brown iron ore. No phenocrysts are present.

*Felsite-Porphry.* A lithoiditic rock, similar to that described above but evidently with some megascopic phenocrysts of feldspar, occurs in the adit of Mannenkô as a dyke across the vein. It strikes N. 60° E. and dips toward S. E. very steeply. Its thickness is 2 meters or more.

Under the microscope, the groundmass is similar in composition and structure to the felsite described above. It is in places intensely stained with clusters of grains of secondary brown iron ore. Feldspar phenocrysts are usually intensely kaolinized, and some-

times entirely or partially replaced by calcite. Quartz of secondary infiltration is occasionally found as patches and veinlets.

*Effusive Liparite.* Besides the felsitic rocks in the form of dykes, a liparite as an effusion is extensively developed on the ridge between Akénobé and Mikobata. It covers the dioritic rocks which constitute the main bulk of the mountain under consideration. It is gray or brownish gray in colour, compact in texture, and contains abundant phenocrysts of feldspar and quartz.

Under the microscope, the groundmass consists of light brownish glassy matter contaminated with abundant globulites and margalites, and contains more or less feldspar microlites and minute flakes of biotite. Fluidal structure is not conspicuous. As phenocrysts, quartz, feldspar and biotite are abundant, ranging from a microscopic size to 2 or 3 mm. in length. Quartz occurs as bipyramidal crystals and fragments, and is often magmatically corroded. Feldspar occurs in the form of tabular crystals and also as corroded fragments. Both sanidine and plagioclase are present, but the former is more common. Biotite occurs in hexagonal plates, usually full of magnetite grains.

*Porphyrites.* Dykes of exceedingly altered porphyrites with macroscopic phenocrysts of feldspar occur here and there in the vein district under consideration. For instance, the dyke exposed across the Higashiyama vein, striking E.-W. and dipping steeply toward S., belongs to this category. It is entirely altered to a gray earthy matter, but still retains a porphyritic structure. A similar porphyrite dyke is found in the underground workings in the Daikoku adit in the Daijūkō area, striking N. 30° W. and dipping steeply toward S. W. These rocks are often so altered that they may be crushed to powder between the fingers, and consequently it is impossible to make thin sections.

Near the deposit of the Minamidani mine, a porphyrite is exposed as a dyke through the phyllitic slates. It is extremely altered and has become light brown in colour, but porphyritic feldspar is abundantly recognizable. Under the microscope, the groundmass is composed of lathy crystals and irregular grains of feldspar, mingled with abundant scales and flakes of brownish green chlorite. No glass-base is present; it has probably been entirely devitrified. Minute apatite needles are common as an accessory mineral. Plagioclase as phenocrysts, sometimes attaining a length of 5 mm., is usually exceedingly altered, although the characteristic polysynthetic twin-lamellae are indistinctly recognizable. It is always kaolinized to a considerable extent. Clusters of prisms and ill-defined crystals of clinozoisite and epidote are often developed in the altered plagioclase. Phenocrysts of ferromagnesian minerals are entirely decomposed to greenish brown chlorite with rather irregular outlines, and the identification of the original minerals is hardly possible; occasionally, however, the outlines resembling hornblende crystals are observed.

A dull-lustered green porphyrite is exposed along the highway about 1/2 km. north of the village of Akénobé. It is intrusive in the green slates. As can be seen under the microscope, the rock is extremely altered. The groundmass is difficult to resolve even under high magnification, but it is clearly observed that a secondary feldspathic substance in irregular grains is its chief component, and it is admixed with abundant kaolin and fine fibers and scales of sericite. Apatite needles remain unaltered in the groundmass. The original feldspar phenocrysts are entirely altered to saussurite. Sometimes they are represented by a confused aggregate of grains and prisms of clinozoisite only, and sometimes by an irregular aggregate of grains of newly developed feldspar in



intimate mixture with grains and prisms of clinozoisite. Chlorite occurs in irregular flakes, representing probably the relics of the original ferromagnesian minerals. This rock may be classed as saussuriteporphyrite.

*Diabase.* A dark green rock, called basalt by local miners, occurs as a dyke with a width of about 2 meters, striking N. 60° W. and cutting across the southeastern part of the Daisen vein. It is compact in texture, but is apt to decompose easily into earthy brittle rock when exposed to the air. It is fine-grained and no phenocrysts are recognizable with the naked eye, though sporadically small amygdaloidal cavities filled with calcite and zeolite are observed. Under the microscope, it is generally extremely altered as might be expected, although the original intersertal and ophitic structures are but indistinctly preserved (Pl. III., Fig. 5). Feldspar is entirely altered to kaolin and shows rectangular and long prismatic outlines, being commonly less than 0.5 mm. in length. Ferromagnesian minerals are all altered to chlorite which occurs abundantly in flaky and filmy forms and fills up the interstices between the lathy feldspar crystals. The chlorite is usually contaminated with dusty particles of hematitic iron ore. Sparsely, phenocrysts of feldspar entirely replaced by a zeolite or calcite are found. Minute octahedrons of magnetite are abundantly scattered through the rock. Irregular-shaped cavities as well as the interstices between decomposed feldspar and secondary chlorite are filled with a biaxial zeolite, frequently partially replaced by later infiltrated calcite.

A similar diabase is found in the abandoned adit of Mannenkô as a dyke across the vein.



### (E) Faults.

It is not surprising that numerous faults have been encountered in underground workings in this highly disturbed district. In the field, many faults are disclosed by the topography as well as the shifting of the outcrops of rocks and veins. In this district, almost all valleys are fault-valleys. That numerous faults with no surface expression are also present is indicated by the fact that the veins of this district are often exposed in the form of short fragments cut sharply at both ends. The veins themselves commonly represent fissures formed by dislocation, accompanied with slickensides and brecciation, although they are naturally older than the faults cutting them. Some conspicuous faults are shown on the annexed geological map (Pl. I.). Two of the most remarkable, namely, faults the Akénobé fault and the great cross fault of the Daisen vein, are specially considered here.

*The Akénobé Fault.* This is a N.-S. fault, passing through the village of Akénobé. On the north of the village, it runs along the Akénobé River, while on the south it runs along the flank of the ridge to the west of the Daidô mine (Pl. I.). It seems to dip steeply toward the west. This fault is very significant in this district, because it sharply separates the Paleozoic terrane from the Mesozoic. The foot-wall side of the fault consists of the green slate complex of the Paleozoic age, and the hanging-wall side of the Mesozoic black slate complex. To the north of the village of Akénobé, on the opposite side of Higashiyama, this fault is well disclosed by topographic features. There it is expressed by a valley between the high precipitous ridge consisting of the black slates on the west side and the low isolated mountain consisting of the green slates on the east. This fault is traceable further northwards.

*The Cross-Fault of the Daisen Vein.* This is the most significant fault for practical purposes in this vein district. It lies to the northeast of the Daisen mine and strikes N. E., consequently all the important veins of the Daisen vein group, striking N. W., are cut at right angles by it (Pl. I.). The fault is utilized for the cross-cut and the main transportation-level connecting the main levels of the Daisen, Nihonmatsu, Sekiei, Hyakken and Shôtoku veins. It is expressed at the surface as a valley and is indicated by the discontinuance of the outcrops of the veins and rocks.

#### IV. THE VEINS IN GENERAL.

Innumerable veins occur in the district under consideration, and in ancient times, especially in the eras of Daidô (806–809) and Entoku (1489–1491), they were prosperously worked for silver and copper. About thirty years ago this vein district was included in the concession to the Mitsubishi Mining Company. In the early times of prospecting and mining by the present company, the extracted ores were treated as argentiferous copper ore. But recently it was discovered that the siliceous ore containing abundant thin plates of wolframite, sometimes in association with chalcopyrite, contains also much cassiterite in microscopic crystals and grains, and now as much tin ore as copper ore is produced from this district. In fact, the Akénobé mine is the largest tin mine in this country at the present time.<sup>1)</sup>

Veins are occasionally found in the dioritic rocks, but most of them occur in the Paleozoic and Mesozoic terranes, particularly in the green slates. Many veins were once prospected or worked

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1) The recent tin production of the Akénobé mine has been :—

1917	377,037 pounds
1918	312,474 „

out. Those now being worked are Daisen, Nihonmatsu, Sekiei, Hyakken, Shôtoku, Daidô, Ebisu, Daikoku and Minamidani. The Daisen vein is the champion lode and produces more tin ore than any other in this district, as well as some quantities of copper ore. Nihonmatsu, Sekiei and Daidô veins also produce tin as well as copper ore. The veins of Hyakken, Shôtoku, Ebisu and Daikoku are worked for copper ore, although a small quantity of tin-stone is commonly contained in them. The Minamidani deposit belongs to a quite different type,<sup>1)</sup> and is worked exclusively for copper ore.

The important veins in this district may be divided into three groups according to the strikes, viz., (1) the Daisen vein group or the veins striking N.W.-S.E.; (2) the Daidô vein group or the veins striking N.-S.; (3) the Daijukô vein group or the veins striking E.-W.

### The Daisen Vein Group.

The Daisen vein and its parallel companions, namely, Nihonmatsu, Sekiei, Hyakken and Shôtoku veins are most important as ore-producers at the present time. They all strike N.  $40^{\circ}$ - $50^{\circ}$  W.

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1) The Minamidani deposit lies on the northwestern flank of the peak of Suruga-miné, at a height of about 600 meters above the level of the Akénobé River. It is about 4 km. north-east of the village of Akénobé. It is found in the Paleozoic terrane, but the country rocks are remarkably different from those in the copper-tin vein area. Besides green slates, phyllitic rocks including calcareous phyllite with much epidote, radiolarian slate, etc.—evidently more or less dynamo-metamorphosed slaty rocks, are dominant. They strike N. E. and dip toward N. W. at  $30^{\circ}$ - $40^{\circ}$ ; the general strike and dip thus coincide with those in the copper-tin vein area. The deposit is a bedded vein of compact cupriferous pyrite having a lenticular form, 3 meters or more thick in the thickest portion, and contains 4 to 5 per cent of copper on an average. Magnetite occurs in admixture with pyrite, and in places it forms black compact masses in place of pyrite. Toward the boundary of the deposit the ore becomes quartzose and grades finally into quartz masses. The deposit is much faulted. Near the deposit under consideration a large porphyrite dyke is found (p. 25).

This belongs to a quite peculiar type of ore deposit, being a dynamically metamorphosed, bedded, epigenetic deposit, evidently different in origin from the copper-tin veins in the Akénobé district, with which the present paper deals. It is noteworthy that a deposit of the same character is met with on the main level driven along the Ôtaké vein, which belongs to the Daisen vein group, the latter cutting the former (p. 33).

and dip very steeply to N. E., and are enclosed in the green slate complex.

*The Daisen Vein* is exposed on the steep slope of Shiroiwa-daké, on the eastern side of the Akénobé River, and is continuous for more than 600 meters along its strike. Its width varies from a fraction of one meter to 5 meters or more. It is the champion lode in this district and produces tin and copper ores. The structure of the vein is very characteristic and affords instructive data as to the history of the vein formation in this district. It will be fully described and discussed in a subsequent chapter (p. 39).

*The Nihonmatsu Vein* lies to the north of the Daisen vein. It is a typical copper-tin vein resembling the Daisen vein in structure as well as in many other points, and plays a very important part as a tin ore producer in this district. It is developed for more than 400 meters along the strike, the thickness varying from a fraction of one meter to 3 meters or more. Toward the southern end, the vein ramifies into two branches and becomes poorer in ore-content.



Fig 6. View of Shiroiwa-daké (S), as seen eastward from the Meisei mine.

N = Nihonmatsu mine.

The remaining three veins, Sekiei, Hyakken and Shōtoku, are exposed on the same rugged mountain slope, far above the Daisen vein. They lie at a distance of about 150 meters from one another, and some of them are traceable for more than 300 meters along the strike.

*The Sekiei Vein* which lies between the Nihonmatsu and Hyakken veins is worked for both copper and tin ores; especially toward the deeper portions it seems to become richer in tin-stone as well as in thin plates of wolframite, thus resembling the Daisen vein in character.

*The Hyakken Vein* contains rather insignificant quantities of cassiterite and wolframite, and these only in deeper zones, so that at present it is worked exclusively for copper ore. It often shows a symmetrical crustified structure (Fig. 7), consisting of quartz, fluor spar and chalcopyrite. The outermost or first crust consists of quartz with specks of chalcopyrite and bornite, at depths in association with very small quantities of wolframite and cassiterite; the second crust is composed wholly of fluor spar; the third crust is of massive chalcopyrite usually as an irregularly pinching and swelling band; the last crust is composed of barren quartz showing in places a comb structure or a drusy structure with a lining of rock crystals. Occasionally the vein in question produces a ring-ore consisting of concentric layers of quartz and sulphide ores, chiefly chalcopyrite and zincblende. It is very characteristic that the ring-ore found in this vein contains little or no cassiterite, while in the Daisen, Nihonmatsu and Sekiei veins this mineral forms one of the essential components of the ring-ore.

*The Shōtoku Vein*, though recently opened and only a little prospected, proves to contain almost no tin-stone, and is expected to be worked exclusively for copper ore.



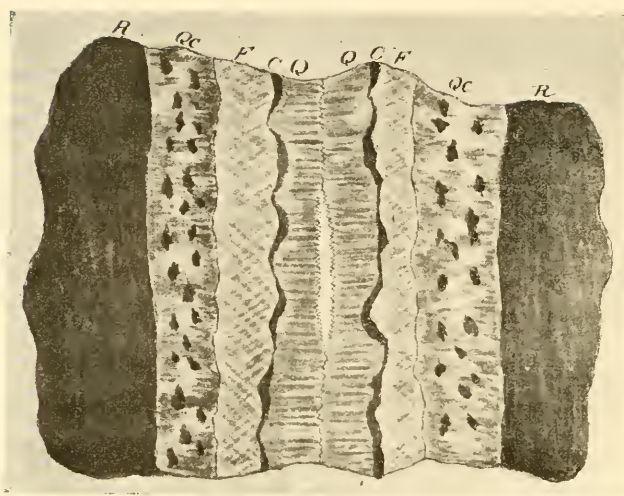


Fig. 7. Diagrammatic sketch of vein piece from Hyakken, showing symmetrical crustified structure.

R, country rock; Qc, quartz with specks of chalcopyrite and bornite, rarely with wolframite plates; F, fluorspar; C, chalcopyrite; Q, quartz.

It is very striking that the above-mentioned parallel veins are diverse in character, in spite of the fact that they are located in a limited area. The tin content is largest in the Daisen vein and decreases gradually toward the northeastern part of the area; the Daisen and Nihonmatsu veins contain much cassiterite and are worked for tin ore as well as copper; the Sekiei vein contains less cassiterite than the above two; the Hyakken vein contains only an insignificant quantity of tin ore and is worked chiefly for copper ore; the Shōtoku vein is believed to contain almost no tin-stone.

Besides the above-mentioned parallel veins, there are a few veins<sup>1)</sup> belonging to the same group, or running in the same

1) The Mannen vein, and Kusakané and other veins to the south of the Daisen mine belong also to this group. The Kemuriyama vein, on the southern side of the Akénobé River, just opposite to the Mannen vein, belongs also to this group. It is a copper-tin vein, and rich tin ore was once extracted from it. The Rin'ei and Shiroiwa veins are nothing but faulted and separated blocks of the Daisen vein.



direction, which were once worked or entirely worked out and abandoned, the Ôtaké and Higashiyama veins being most prominent.

*The Ôtaké Vein*, which runs parallel to the Nihonmatsu vein and about 200 meters distant from it to the northeast, was once worked for copper and tin ores. It is similar to the Nihonmatsu vein in character, and is traceable for about 400 meters along the strike, with a width varying from a fraction of one meter to several meters. In the course of driving the main level, a bedded deposit of cupriferous pyrite, intersected by the copper-tin vein in question, was encountered. The wall-rocks are green slates in association with phyllites striking N. 50° E. and dipping 15°-25° to N. W. This bedded deposit is similar in character to that which is being worked at the Minamidani mine (p. 29). It is lenticular in form, 2 meters or more thick, and is associated with magnetite, especially along the hanging and foot-walls, which are often intensely silicified and grade into massive quartz. The high-grade ore from this deposit contains 7% or more copper.

*The Higashiyama Vein*, once worked prosperously but now temporarily abandoned, lies in the northern vicinity of the Ôtaké vein. It is exposed for more than 300 meters along the strike, attaining in places a thickness of several meters. It was worked for copper and tin ores as in the Ôtaké vein.

### The Daidô Vein Group.

The Daidô vein group lies on the western side of the Akénobé River, just opposite to the Daisen mine. Two chief veins are found there, namely, Uwaban-hi (roof-vein) and Shitaban-hi (floor-vein), both varying in width from a fraction of one meter to 2 meters or more. They generally strike N.-S. and dip eastward very steeply, but they intersect as indicated in Pl. I. They are in places re-

presented by a shattered zone heavily mineralized with chalcopyrite in the form of networks, streaks, patches and impregnation, accompanied by varying amounts of quartz. Sometimes they occur as simple fissure-filling veins showing an irregular massive, or in places banded, structure. Quartz is the principal gangue mineral, and chalcopyrite the chief ore. In the roof-vein, insignificant quantities of wolframite and cassiterite are associated.

Another small vein cutting the two N.-S. veins diagonally, i.e., striking N. E. and dipping northwestward, is found on the northern side of the intersection of the two veins. It is a fault vein, accompanied by conspicuous slickensides, brecciation and shifting of the cut veins, and is richly mineralized with chalcopyrite, especially at the intersections with the preexisting veins.

The above-mentioned veins are worked chiefly for copper ore, but a small quantity of tin ore is also extracted from them.

*The Meisei Vein*, which lies about 600 meters north of the Daidô mine, belongs to the same category. It strikes N.-S. as in the Daidô veins, but dips westward. In places it is represented by a shattered zone, giving rise to a stockwork deposit, from which very rich tin ore was much extracted, especially from the oxidized zone stained with limonite. At present, this mine is temporarily out of work, but it will be worked again by open-cut in the near future. On the hanging-wall side of the vein, adjacent to it, a fault with the same strike is developed. A gabbroid diorite is exposed along the hanging wall of the fault, being cleanly cut by it.

All veins belonging to the Daidô vein group, such as those of the Daisen group, are enclosed in the green slate complex.

### The Daijukô Vein Group.

The Daiju mine lies about 1 km. southwest of the village of Akénobé. The country rock consists of Mesozoic black carbonaceous slates or shales interstratified with sandstone and others. The shales are in places intensely silicified and chloritized. The general strike and dip of the complex are N.  $20^{\circ}$ - $40^{\circ}$  E. and N. W. at  $20^{\circ}$ - $40^{\circ}$  respectively, thus being slightly different from those of the green\_slate complex in the Daisen area.

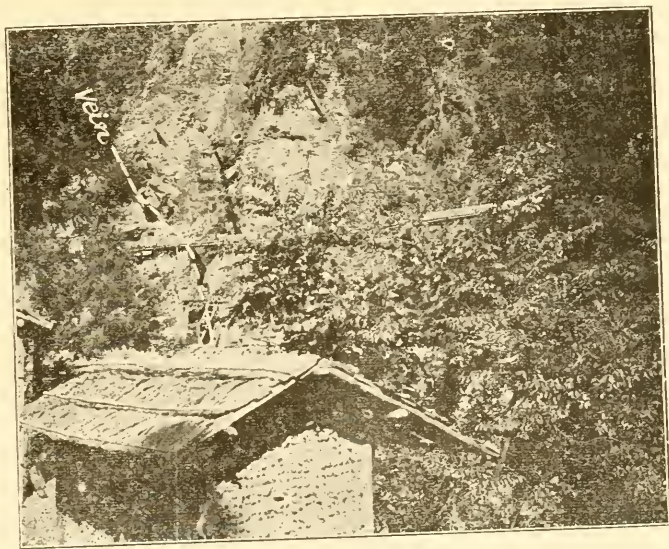


Fig. 8. A view of the Daikoku adit.

There are two main veins in this area, namely, Yebisu and Daikoku, both varying in width from a fraction of one meter to 1 meter or more (Fig. 8). Their strike ranges between E.-W. and N.  $60^{\circ}$  W. and they dip northward very steeply. These veins are worked chiefly for copper ore, but produce insignificant amounts of thin plates of wolframite and microscopic grains of tin-stone, their mineralogical composition being thus in accord with the Hyakken vein of the Daisen vein group. Moreover, a banded

structure showing the same order of mineral depositions as in the Hyakken vein (Fig. 7) is sometimes recognizable in them.

*The Fujii Vein*, which lies about 700 meters southwest of the Daiju mine on the upper course of the same valley, belongs to the same vein group, striking N. 60° W. and dipping southward very steeply. It is a small vein varying in width up to 1 meter or so, and was once worked for copper ore. It is noteworthy that abundant gelena is associated with chalcopyrite in this vein, while no tin-stone is recognized.

*From the foregoing description, it is clear that the veins of the Akénobé district are all consanguineous, and all gradations exist between the copper veins containing little or no cassiterite and the copper-tin veins containing much of the same mineral.* The scope of the present paper is to investigate fully the origin of the *copper-tin veins* of this district.

## V. THE ORE-BRINGER.

The ore-bringer for the copper and copper-tin veins of the Akénobé district has long remained problematic.<sup>1)</sup> It is generally accepted that tin veins are usually associated with *intrusive* acid igneous rocks such as granites, quartz-porphyrries and others,<sup>2)</sup> but rarely with *extrusive* acid rocks such as liparites.<sup>3)</sup> The associa-

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1) In the previous paper ("The Ring-Ore from the Akénobé Mine," loc. cit., p. 36), the writer has suggested that "the veins seem to be related to the liparitic rocks, though not proved," but this has been disproved by later reconnaissances.

2) Summarized by H. G. Ferguson and A. M. Bateman, "Geologic Features of Tin-Deposits," Econ. Geol., Vol. VII., 1912, p. 209 et seq.; J. T. Singewald, jr., "Some Genetic Relations of Tin-Deposits," Econ. Geol., Vol. VII., 1912, pp. 263-279; and R. H. Rastall, "The Genesis of Tungsten Ores," Geol. Magaz., No. VIII., 1918, p. 368.

3) Certain tin veins in Mexico are associated with Tertiary rhyolites and rhyolitic tuffs (W. R. Ingalls, "The Tin-Deposits of Durango, Mexico," Trans. Am. I. M. E., Vol. XXV., 1895, pp. 116-163).

A few of the Bolivian tin veins are also related to rhyolites (M. Armas, "Genesis of Bolivian Tin Deposits," Eng. and Min. Journ., Vol. 92, 1911, pp. 311-314).



tion of cassiterite-bearing veins with intermediate rocks is only exceptional.<sup>1)</sup> In the Akénobé district no granitic or allied acid plutonic rocks have been observed. Dykes of liparitic rocks are rather scarce, although a liparite flow is extensively developed on the ridge between Akénobé and Mikobata. Dykes of porphyrites and andesites are of commoner occurrence. Those dykes commonly cut the veins intricately, and are clearly later in generation than the latter.

To the writer, the veins of this district seem *to be related to the dioritic rocks*, particularly to the later offshoots from the main diorite magma. As has been fully stated in a previous chapter, of the parallel veins belonging to the Daisen vein group Daisen and Nihonmatsu are most characteristic as copper-tin veins, Hyakken and Sekiei contain only a small quantity of tin-ore, and the easternmost vein, Shôtoku, contains little or no tin-stone. The decreasing tin-ore content toward the east suggests that the ore-bringer lies nearer to the Daisen vein. The only mighty igneous mass exposed near the Daisen, Nihonmatsu and Sekiei veins is the large dyke-like offshoot of the altered diorite (Pl. I.).

In the Higashiyama area, a leucoeratic igneous rock, *akenobeite*, corresponding in composition to quartz-monzonite-pegmatite or aplite,

1) Many tin veins, once supposed to be connected with intermediate rocks, have been proved to have a close relation to acid rocks. For instance, some Bolivian tin veins were thought by Stelzner to be connected genetically with andesitic rocks (A. W. Stelzner, "Die Silberzinnerzlagertstätten Boliviens," Zt. der deutsch. geol. Gesellsch., Bd. 49, S. 51-142, 1897), but W. R. Rumbald ("The Origin of the Bolivian Tin Deposits," Econ. Geol., Vol. 4, 1909, pp. 321-364) and M. Armas (op. cit.) state that the Bolivian deposits are invariably connected with acid rocks, viz., granitic and liparitic rocks.

The Suzuyama veins in the province of Satsuma, Japan, were supposed to be connected with an andesite, but recently it has been proved that they occur in connection with a granite-porphyry (T. Iki, "Report on the Suzuyama Mine," Bull. No. 46 (in Japanese), Imp. Geol. Survey of Japan, 1914; T. Katô, loc. cit.).

At the present time, most investigators infer that the tin veins are, without exception, genetically connected with acid igneous rocks, i.e., granites, quartz-porphyries, rhyolites and others.

forms a small boss in association with dioritic offshoots, near the chief vein. This rock clearly represents, as already discussed, an acid segregation from the dioritic magma, and it is, in all probability, connected genetically with the adjacent vein.

The Daijukô parallel veins are probably related to the altered diorite mass exposed along the road leading from Akénobé to Fudono.

In conclusion, it seems highly probable that the ore-bearing solutions rose from deeper and at the time unconsolidated portions of the magma through the upper solidified portions. It is suggested by the presence of a boss or an apophysis of the leucocrate, akenobeite, that the later solidified portions of the magma were acid in nature and rich in volatile mineralizers due to a process of magmatic differentiation. It is also probable that in the future more offshoots of diorite and acid differentiation-products will be discovered in this district by underground explorations.

## VI. THE COPPER-TIN VEINS.

Under this heading the writer confines himself to the structure, character of mineralization, and alteration of the wall-rocks of the Daisen vein, of which more complete observation and more careful study of thin sections have been made than of any others. As a matter of fact, the Daisen vein is worthy to be taken as representative of the copper-tin veins of this district, since it is the most productive vein and other veins now being worked or once worked, such as the Nihonmatsu, Sekiei, Ôtaké, Kemuriyama, etc., show a striking similarity to it. Consequently, the conclusions derived from the Daisen vein apply to the remainder of the similar veins in this district.



The vein is composite in structure. It represents a shattered zone filled with ores, gangue minerals, and fragments of partially, or entirely altered country rock, and the filled fissures have been repeatedly reopened and recemented by successive mineralizations (Fig. 9). In some places, however, the structure of the vein is very irregularly massive and brecciated.

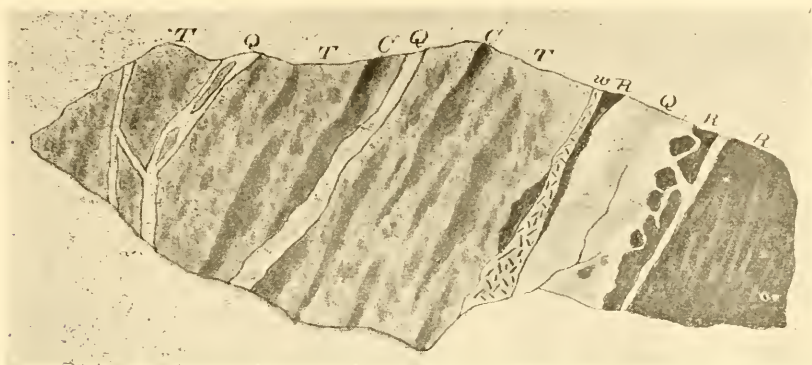


Fig. 9. Diagrammatic sketch of a vein-piece from Daisen. About  $1/5$  natural-size. R, country rock; T, cassiterite ore of the first stage of mineralization, with specks and streaks of chalcopyrite, etc.; w, quartzose wolframite-cassiterite ore of the second stage of mineralization; C, chalcopyrite veins and veinlets of the third stage of mineralization; Q, milky quartz with a little chalcopyrite (fifth stage of mineralization). Zineblende veinlets of the fourth stage of mineralization are not represented here.

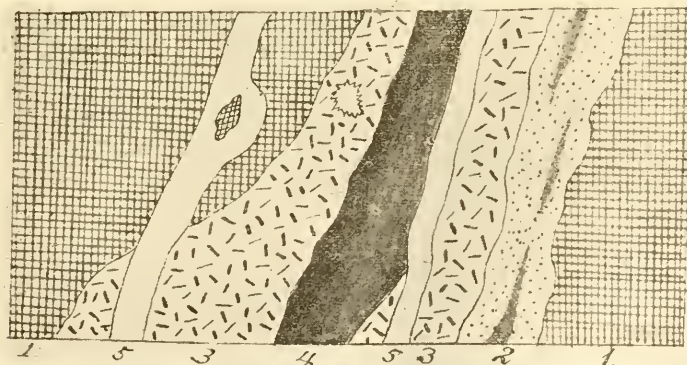


Fig. 10. Diagrammatic sketch of the exposure at a working place in the northern part of the Daisen vein (Kominé).

1, country rock; 2, copper-tin ore; 3, wolframite-bearing tin ore; 4, copper ore; 5, barren quartz.

The composite nature of the vein and evidence of re-opening of the fissures are well observed at many working places. The diagrammatic sketch of a vein-specimen from a working place in the northwestern part of the Daisen vein, shown in Fig. 9, and that of the exposure at another working place of the same vein shown in Fig. 10 illustrate its composite nature very well.

On observing the vein at the working places and examining the vein-specimens in the laboratory, we can recognize five successive stages of mineralization in the history of the formation of the vein under consideration, viz., (1) deposition of the main cassiterite ore, (2) deposition of wolframite-cassiterite ore, (3) deposition of chalcopyrite, (4) deposition of zincblende, (5) deposition of barren quartz, with a little chalcopyrite.

#### (1) The Deposition of the Main Cassiterite Ore.

After the formation of the vein fissures and the brecciation of the wall-rocks along them, the main mineralization took place. By the action of the mineralizing solutions which ascended through the fissures, the wall-rocks as well as the blocks and fragments of the country rock filling the fissures underwent conspicuous alterations, chiefly silicification. The solutions at this first stage of mineralization were very siliceous. The rock-fragments in the vein occasionally show intense sideritization instead of silicification, being partially or entirely converted to granular aggregates of siderite.

The product of this stage is the main cassiterite ore consisting chiefly of quartz with abundant cassiterite. The cassiterite is very minute in size, ranging from a microscopic size up to 1 mm. in length, and is irregularly scattered in quartz in the form of grains and ill-defined short prismatic crystals.

The high-grade ore of this stage is a quartzose ore containing abundant cassiterite in clusters, and has a dark gray or dark brown colour. Under the microscope, the cassiterite is always the earliest crystallized mineral and is enclosed in irregular grains or hypidiomorphic crystals of quartz.

The main cassiterite ore is sometimes represented by a *ring-ore*,<sup>1)</sup> which is especially well developed in certain parts of the Daisen vein. The ring-ore is formed in places where fragments of the country rock abound. It is composed of layers of quartz and cassiterite deposited successively along the altered rock-fragment, thus giving rise to an aggregate of concentric banded rings (Pl. V., Figs. 2, 3). As can be observed macroscopically and microscopically, the rock-fragments forming the nuclei of the rings are extremely silicified and sometimes almost entirely altered to an aggregate of minute quartz grains, but they are rarely partially or entirely sideritized.

The first crust formed on the fragments consists of quartz and cassiterite; microscopic grains and crystals of cassiterite forming a concentric streak (Pl. V., Fig. 2) are enclosed in the quartz crust. Sporadically the rock-fragments are directly surrounded by the cassiterite band which is encrusted with a quartz layer; this is a special case and under the microscope a certain amount of quartz is always found mingled with cassiterite. The second crust is very characteristic. It is composed of *chalcedony*. On keen observation, we can recognize a concentric layer with a thickness of 3-5 mm., covering the first quartz-cassiterite layer, and having a luster resembling wax, with a pale blue colour (Pl. V., Fig. 2). Under the microscope, it is essentially a fibrous aggregate showing a radial and concentric structure (Pl. VI., Figs. 1, 2, 3). The fiber shows

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1) T. Katō, "The ring-ore from the Akénobé mine," loc. cit.

an optically negative character along the longer zone, the greatest elasticity-axis existing along the longer axis. Refraction is always a little higher than that of Canada balsam. It is  $\text{SiO}_2$  in chemical composition. These properties correspond exactly with those of chalcedony. The third crust is represented again by a quartz layer, which is the last zonal precipitation in the stage of ring-ore formation. Occasionally, if not always, a second cassiterite-bearing band, macroscopically an insignificant dark streak, is developed concentrically in the last quartz crust (Pl. V., Fig. 2). Rarely, however, is this band represented by a thick cassiterite layer, in which case the ring-ore contains two concentric cassiterite layers. This quartz zone is characterized by numerous small drusy cavities lined with small crystals of quartz, which are sometimes encrusted with fine crystals (cubes) of colourless or light purple fluorspar, pyramidal crystals of light brown scheelite, and minute crystals of siderite.

Zincblende sometimes plays an important rôle in the formation of the ring-ore. Exceedingly silicified rock-fragments are occasionally encrusted with a zincblende layer, a few millimeters thick, and subsequently covered successively by the quartz-cassiterite, chalcedony and other layers. In places the nucleus of the ring-ore has been heavily impregnated with, or entirely replaced by, zincblende. Chalcopyrite and bornite play also a significant part in the ring-ore. They occur as an admixture in the cassiterite-bearing crust commonly in the form of small specks, or sometimes are deposited directly on the nuclear rock-fragment. Frequently they are scattered in the form of minute grains and streaks through the silicified rock-fragment. It is certain that at an early epoch of the ring-ore formation small quantities of zincblende, chalcopyrite and bornite have been deposited from the vein-forming solutions, the cuprififerous



sulphides being evidently of later deposition than zineblende. Pyrrhotite occurs also as an early precipitation in this stage, sometimes enveloping cassiterite.

The ring-structure in the ore of the first stage of mineralization is often obliterated and rendered obscure by later impregnation of chalcopyrite and other sulphides of the third stage of mineralization. The ore of this stage, showing no ring-structure and consisting of massive quartz with abundant cassiterite, is not infrequently cut by innumerable veinlets and streaks of chalcopyrite, and is heavily impregnated with the same mineral belonging to the third stage of mineralization, giving rise to a massive siliceous chalcopyrite-cassiterite ore (Fig. 9).

Toward the end of this stage, small quantities of siderite, fluorspar, scheelite, and again some sulphides such as pyrite and chalcopyrite were precipitated. It has already been stated that in the ring-ore, siderite, fluorspar and scheelite occur as linings of the drusy cavities. Moreover, siderite in irregular specks occurs as a filling of the interstices between quartz grains. Pyrite and chalcopyrite occurring as impregnation in quartz in close association with siderite belong also to this stage.

The products of the first stage of mineralization, particularly the chalcedony<sup>1)</sup> in the ring-ore, afford very instructive data as to the genesis of the Akénobé veins. Though the temperature limits in which chalcedony is formed are not yet experimentally determined, it is certain that this mineral has never been found in pneumatolytic deposits characterized by high temperature gangue minerals. J. Königberger and W. J. Müller<sup>2)</sup> observed that gelati-

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1) It was told by a mining engineer that in a part of the Daisen vein a similar chalcedony was once found as crustified layers along the selvages. But such an occurrence is of extreme rarity.

2) Königberger und Müller, "Versuch über die Bildung von Quarz und Silikaten," Centrbl. f. Mineralogie usw., 1906, S. 371.

nous silica was deposited at 360° C., but they believe that at this temperature the material is unstable and would soon be converted to quartz. This is the highest temperature at which the gelatinous silica has been synthesized.

The work of Hein, Leitmeyer and others<sup>1)</sup> leads to the conclusion that chalcedony is in all cases composed of quartz fibers and that it always results from the crystallization of gelatinous silica either soon after the deposition or at a later time, and that gelatinous silica may in becoming crystalline either turn into granular quartz or into fibrous quartz, i.e., chalcedony.

In the case of the ring-ore now in question, it is evident that the crust of chalcedony represents a gelatinous silica transformed to fibrous quartz as its opaline appearance and globular habit under the microscope clearly suggest (Pl. VI., Figs. 1, 3). Consequently, it is highly probable that the copper-tin veins of the Akénobé district were formed chiefly under pneumato-hydatogenetic or hydrothermal conditions, below the critical temperature of water (364° C).

It is noteworthy that in the Nihonmatsu and Sekiei veins, though a similar ring-ore occurs very commonly, no typical chalcedony has yet been observed. But under the microscope, the quartz crust corresponding to the chalcedony crust of the Daisen ring-ore is revealed to be an aggregate of indistinct broad fibers, probably representing an advanced stage of transformation of opal to quartz.<sup>2)</sup>

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1) Summarized in Doelter's "Handbuch der Mineralchemie," Bd. 2, pp. 165-190, 249-264 (1914).

2) Many examples of transformation of opal to chalcedony and quartz were enumerated by P. Cornu and Leitmeyer ("Über analoge Beziehungen zwischen den Mineralien der Opal-, Chalcedon-, der Stilpnosiderit-, Hämatit- und Psilomelanreihe") in Zeitschr. f. Chemie u. Industrie der Kolloide (Kolloid-Zeitschrift), Bd. IV., 1909, S. 285-290.



(2) The Deposition of the Quartzose Wolframite-Cassiterite Ore.

A quartzose ore containing abundant wolframite and cassiterite occurs in the form of a vein cutting the composite vein longitudinally, its width varying from a few centimeters to one meter or more. It is most typically developed in the Daisen vein. This ore is the product of the second stage of mineralization, and cuts the cassiterite-quartz ore, including the ring-ore, of the previous stage, often showing well-defined boundaries (Fig. 9). The writer observed at a working place of the Daisen mine a section of the vein which showed the ring-ore of the first stage in contact with the wolframite-cassiterite ore of the second stage. The contact was sharply defined, suggesting that the latter was deposited later along a reopened fissure cutting the former.

The ore in question is practically the same in appearance as the product of the previous stage, except that it contains innumerable thin plates of wolframite (Pl. V., Fig. 1). Wolframite is characteristically paper-like, commonly with a thickness of less than 0.5 mm.; and confusedly scattered black streaks, representing cross-sections of the wolframite plates, are observed on the fracture-surface of the ore. Along the walls of drusy cavities of the ore of this stage, small but beautiful crystals of fluor spar and scheelite are often found.

In places, specks and patches of native bismuth are found in this ore. This mineral is of rare occurrence in the vein under consideration, and occurs exclusively as a product of the second stage of mineralization. Sometimes, it is found in the form of streaks filling up the cracks along the thin plates of wolframite. Still more rarely, bismuthinite is found embedded in quartz. It is often intimately associated with native bismuth, the latter being enclosed

in the former with very irregular boundaries. Chalcopyrite in minute specks is usually intimately admixed with bismuthinite. It is indicated by their modes of occurrence that native bismuth deposited first and that it had later undergone sulphuration which has advanced gradually toward the interior. Fluorspar in small masses is sometimes found in the ore under consideration.

On examining this ore under the microscope, the wolframite shows a long needle-shaped cross-section (Pl. VII., Fig. 5) embedded in an aggregate of quartz grains. This mineral is the earliest to crystallize out. It is sometimes altered to a colourless, transparent, strongly double-refracting mineral—probably scheelite, the alteration-product assuming the original platy crystal often in admixture with remnants of wolframite (Pl. VII., Fig. 5). Cassiterite is the next crystallized mineral. It is usually embedded and enclosed in quartz grains in the form of small crystals and grains. It is a noteworthy fact that minute crystals and grains of cassiterite show a tendency to accumulate along the thin plates of wolframite; in thin sections it is observed that the cassiterite grains and crystals are attached to the slender needle of wolframite like magnetic sands attracted by a magnet. Quartz is mostly of subsequent crystallization to wolframite and cassiterite, and occurs as aggregates of grains enclosing them. But in places well-defined hexagonal prisms of quartz are developed surrounded by grains of the same mineral often showing a zonal structure due to successive growths, and zonally arranged inclusions of fine crystals and grains of cassiterite and others (Pl. VII., Fig. 1). Fluid inclusions are abundant in quartz.

Occasionally a ring-ore similar to that of the first stage of mineralization is found as a product of this stage. The present writer found a typical one of this category in the Sekiei vein, in which two or three cassiterite-bearing layers are usually present

in alternation with quartz crusts. The most characteristic arrangement of the layers in the ring-ore in question, as observed in thin sections, is shown in Fig. 11. The first crust is composed of hypidiomorphic crystals of cassiterite which are frozen to the silicified rock-fragment; the second crust is composed of quartz grains containing sporadic cassiterite crystals; the third crust is made up again of cassiterite crystals; the fourth one consists of large grains of quartz, on the outside of which a broad crust consisting of wolframite plates, cassiterite crystals and quartz grains is developed. In places, these cassiterite-bearing bands unite together and form a wolframite-cassiterite-bearing layer, which is

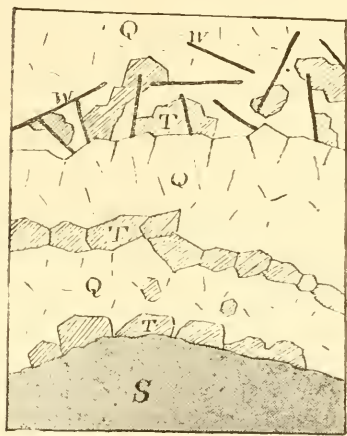


Fig. 11. Camera lucida drawing of a part of the ring-ore from the Sekiei vein. Enlarged about 10 diameters.

S, silicified rock-fragment; T, tin-stone; Q, quartz; W, wolframite.

deposited directly on the rock-fragment. The quartz layer containing wolframite and cassiterite frequently shows indistinct radial fibrous or radial bladed structure, representing probably an advanced stage of transformation of opaline silica to quartz.

*Microscopic topaz in the Daisen vein.* The writer found, in the course of microscopic examination of many thin sections of the quartzose wolframite-cassiterite ore from the Daisen vein, several microscopic crystals of a

colourless mineral. They are embedded in quartz, usually prismatic in habit and frequently showing terminal faces (Pl. VII., Fig. 2). The size ranges from 0.15 to 0.5 mm. in length, no macroscopic crystals having yet been found.

The mineral shows straight extinction and fairly high re-

fringence, much higher than that of the enclosing quartz; consequently its border appears dark and sharply defined. Double refraction is weak, about the same as, or a little weaker than, in quartz. The basal cleavage is well developed. The character of double refraction along the principal axis is negative. Under the conoscope, a biaxial interference figure appears, and it has been determined by means of the gypsum plate that the mineral is optically positive. The basal section is typically rhombic in shape. These properties coincide exactly with those of topaz.

The occurrence of the microscopic crystals of topaz in the ore in question is not surprising, because it is suggested by the presence of fluorspar that fluorine-mineralizers have played an important part in the formation of the copper-tin veins of this district.

### (3) The Deposition of Chalcopyrite.

The deposition of the wolframite-cassiterite ore was succeeded by the deposition of chalcopyrite. This is an important stage of metallization in the vein district now under consideration, but it must be borne in mind that the deposition of chalcopyrite and bornite took place also in the first stage of mineralization, as already stated, although the quantities were insignificant.

The chalcopyrite of this stage forms not only large veins and patches through the composite vein, but also occurs in the form of streaks, stringers and flecks impregnated in the cassiterite-quartz and quartzose wolframite-cassiterite ores. It surrounds and embays all earlier minerals, and fills the interstices between the wolframite plates.

Owing to impregnation with chalcopyrite, the treatment of the tin ores is often rendered very difficult. Thus very rich copper

ores containing a small quantity of cassiterite are extracted from some working parts of the vein, while high-grade tin ores containing more or less chalcopyrite are also being mined at other places of the same vein.

#### (4) The Deposition of Zincblende.

Occasionally veinlets of zincblende with a width varying from a few millimeters to several centimeters are found in the composite vein. They cut through massive chalcopyrite ores, often passing into ramifying stringers. The veinlet consists mainly of granular massive zincblende admixed with varying amounts of quartz. Very small quantities of galena, chalcopyrite and secondary bornite in minute specks are associated with it.

The product of this stage must be distinguished from similar ones of the earlier stages, because zincblende was deposited to a less extent, as already stated, in the first stage of mineralization in association with the cassiterite-bearing ring-ore, and in others.

#### (5) The Deposition of Barren Quartz.

Veins and veinlets of quartz representing the last mineralization are found everywhere in the veins of the Akénobé district. They vary in thickness from a few millimeters to several decimeters and cut the products of all earlier stages, filling the reopened fissures in the composite veins, and either running parallel to the selvages or irregularly across them (Fig. 9). They consist of massive, milky or transparent quartz, and are rich in drusy cavities lined with slender crystals of quartz. A very small quantity of chalcopyrite in the form of small masses and specks occurs sporadically in the veins under consideration; it belongs to the same stage of mineralization as the associated quartz. Considered from an



economic point of view, the quartz veins of this stage are not important.

## VII. THE ALTERATION OF THE CLAY SLATE.

As already stated, the slate complex, particularly of the Paleozoic formation, has been subjected to intense alteration. The metamorphism of the complex by dynamic processes has been fully treated under the heading of general geology. In this chapter the alterations other than dynamo-metamorphism are dealt with, which are connected directly or indirectly with the formation of the copper-tin veins of this district.

### (A) DIOPSIDIZATION OF THE SLATE.

Along some contacts with the dioritic rocks the slate is metamorphosed into light green rocks, occasionally showing intricately contorted, alternating bands consisting of light green compact and deep green granular layers. The deep green granular layer represents an injection of diorite along the bedding-plane, and is composed of crystals and grains of green hornblende with more or less feldspar, while the light green band is composed of silicified slate mingled with abundant patches and streaks consisting of minute short prismatic crystals and grains of colourless diopside. Minute grains of diopside are also scattered through the whole silicified layer (Pl. III., Fig. 2). This layer may properly be called a diopside-hornfels, and is one of the typical products of contact-metamorphism. Alteration of this kind is well observed along the road side between Akénobé and the Fudono pass.

### (B) CHLORITIZATION OF THE SLATE.

The slaty rocks adjacent to the copper-tin veins are usually



altered to dark green rocks. The green slate is not confined to the walls of the veins but covers a considerable area in this vein district. It is particularly well developed in the Daisen area. When the bedding-plane and slaty structure are indistinct, it is easily mistaken for altered diorite which occurs in large dykes or small bosses here and there in the terrane of the green slate complex.

Under the microscope, flakes and fibrous flecks of chlorite are abundantly scattered through a clayey ground, sometimes being arranged along the cleavage-plane, intricately mixed with dusty carbonaceous matter. Frequently, the chloritized rock is represented by sericite-chlorite slate which is made up largely of sericite fibers, minute flakes of chlorite and more or less infiltrated quartz grains—a characteristic hydrothermally altered slate.

The chloritized slate, as well as the chlorite-sericite slate, is in places irregularly traversed by microscopic quartz veinlets which pass gradually into highly silicified rock-portions (Pl. II., Fig. 4). It is thus suggested that the main chloritization of the country rock took place prior to the main silicification.<sup>1)</sup> That the chloritization of the slate is intimately related to the vein-formation is indicated by the fact that the alteration is most intense in the area rich in veins.

#### (C) SILICIFICATION OF THE SLATE.

The slate adjacent to the veins is often intensely silicified, resulting in a hard quartzose rock usually mottled with light brownish and greenish colours. The silicified slate is commonly cut by netted veinlets of a reddish brown colour.

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1) A subordinate silicification had taken place prior to the main chloritization, the slate being in places altered to an aggregate of fine quartz grains, which are overlapped by later infiltrated chlorite flakes.

Under the microscope, the rock is found to be almost entirely composed of fine anhedral grains of quartz, and shows a quartzitic structure, penetrated irregularly by microscopic veinlets consisting of somewhat larger grains of quartz (Pl. II., Fig. 3).

The reddish brown veinlets cutting the silicified slate are revealed, under the microscope, to consist of siderite and limonite, the latter mineral being an alteration-product of the former. It is evident, therefore, that the silicification took place prior to sideritization. This will be fully considered in a subsequent article.

#### (D) EPIDOTIZATION OF THE SLATE.

In certain places in this district, the clay-slate is intensely epidotized. This alteration is best observed in the environs of the Mannen adit and near the western entrance of the Myôjin tunnel, in the southern part of the vein district under consideration. There, the black slate is intricately penetrated by netted veins and veinlets and irregular patches of bright green epidote, occasionally in association with brick-red patches, thus giving rise to a confusedly mottled appearance of black, green and red colours.

The bright green patches and veinlets are composed of epidote, chlorite and quartz, as is revealed under the microscope. Epidote occurs in hypidiomorphic grains and idiomorphic prisms, and shows distinct pleochroism, bright green to light yellow, and bright speckled interference colours (Pl. II., Fig. 2). Quartz occurs in xenomorphic grains and encloses epidote, slightly pleochroic green chlorite in the form of flakes sometimes occurring in place of quartz.

The brick-red patches are composed of quartz full of hematite dust, which is sometimes arranged in a radial manner. These

patches are often cut irregularly by the above-mentioned epidote veinlets. These ferruginous patches are evidently of secondary infiltration into the slate, and the epidote-bearing veinlets and patches are of still later formation, since the former are traversed by the latter.

A similar alteration is also typically developed in the green slate in the environs of the veins of Hyakken and Sekiei. There, veinlets and patches of epidote are abundantly found in the form of parallel bands along or across the indistinct bedding-planes.

Minor epidotization of the slate complex, microscopic as well as macroscopic, is observed very extensively in this district. The chloritized and silicified slate, already described, contains frequently more or less epidote in association with quartz grains.

The epidotization is evidently later than the chloritization of the slate, because epidote usually invades chlorite flakes, and veinlets of epidote cut the chloritized slate very sharply. On the other hand, it is clearly prior to the sideritization which is described in the next article, because epidote veinlets are traversed definitely by those of siderite.

The fact that crystals and grains of epidote always occur in association with quartz grains and the veinlets of epidote grade frequently into those consisting exclusively of quartz, indicates that the epidotization now under consideration is a special phase of the silicification, already considered.

#### (E) SIDERITIZATION OF THE SLATE.

The wall-rocks, particularly the silicified slate just adjacent to the veins, are commonly coloured reddish brown to brown, and are often penetrated by minute netted veins of a dark brown colour. This is one of the most striking characters recognizable by every

keen observer. On close examination under the microscope, these rocks are always found to be intensely sideritized.

The reddish brown colour of the rock is due to the presence of abundantly and irregularly scattered flecks and innumerable microscopic netted veinlets of iron hydroxide. The iron hydroxide is yellowish brown in colour and shows indistinct aggregate-polarization-colours due to aggregation of microscopic grains. This is cryptocrystalline limonite.<sup>1)</sup> That the limonite is derived from siderite by oxidation and hydration is clearly indicated by the following facts:—(1) Sometimes, in the interior of the flecks and veinlets of limonite a core of unaltered siderite is preserved; (2) the brownish veinlet often passes gradually into a vein consisting of strongly pleochroic carbonate (siderite); (3) in places, the country rock is heavily impregnated with siderite flecks, and is penetrated by netted veinlets of the same mineral, along the borders of which a change to brown hydroxide of iron is frequently observed (Pl. III., Fig. 1).

Small amounts of chlorite in irregular flakes have been formed in the stage of sideritization, since they are closely associated with siderite flecks in the sideritized rock and in the veinlets of siderite. On the other hand, the siderite flecks overlap the quartz grains in the silicified slate, and the siderite veinlets cut the same rock. The chloritized slate, too, is sometimes heavily impregnated with siderite and is cut irregularly by netted veinlets of the same mineral. Consequently, it is beyond all doubt that the sideritization has taken place subsequent to the intense chloritization and silicification of the country rock.

*In the country rock adjacent to the veins, no alterations charac-*

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1) A. F. Rogers, "A Review of the Amorphous Minerals," Journ. Geol., Vol. XXV., 1917, pp. 528-529.

*teristic of pneumatolytic processes have been observed even under the microscope, though the diopsidization, a characteristic contact-alteration, is found rather rarely in the slate near, or at the contacts with, the dioritic rocks.*

The chloritization, silicification and sideritization, which the country rock underwent very intensely and extensively, are characteristic of hydrothermal processes.

### VIII. QUARTZOSE VEINLETS CUTTING THE COUNTRY ROCK ADJACENT TO THE VEINS.

The country rock adjacent to the veins is commonly traversed by minute quartzose veinlets, sometimes showing a netted structure. Occasionally they contain cassiterite in association with muscovite and chlorite. In the following paragraphs are described those cassiterite-bearing veinlets found in the wall-rocks of the Daisen vein (Pl. VII., Fig. 3).

They are commonly less than 2 mm. in width, and cannot be distinguished with the naked eye from those of barren quartz. Cassiterite occurs in minute prismatic crystals, often rounded, and is the earliest crystallized mineral. Quartz occurs in idiomorphic and hypidiomorphic hexagonal prisms, its crystallization being hindered only by cassiterite crystals, which are usually embedded in it. Chlorite is the last deposited mineral and fills up the interstices between the crystals of cassiterite and quartz; it is the most abundant constituent. The chlorite is pale green in colour, fibrous to flaky radial in structure, showing a cross-bar between crossed nicols. It shows very weak double refraction, indicated by a gray interference colour. In close association with the chlorite, particularly along the selvages of the veinlets, a mineral in radiated fibers and flakes



showing bright interference colours is found. It is almost colourless or very pale greenish and is distinguishable from chlorite only between crossed nicols. This mineral is most probably muscovite, which has crystallized chiefly along the selvages. The chlorite crystallized soon after the deposition of muscovite, and filled up all the interstices between the earlier minerals.

The veinlets under consideration ramify into stringers containing quartz and sporadic flakes of chlorite, and finally into those consisting exclusively of quartz grains. They are, therefore, contemporaneous in generation with the quartz veins and veinlets of the stage of the main silicification of the country rock. It is further suggested that the stage of the deposition of the main cassiterite-ore corresponds to the stage of silicification.

Veinlets and stringers of siderite-limonite and siderite-chlorite often cut the quartzose veinlets under consideration, though the former have a tendency to be ramified in the latter and to unite to larger veinlets in the silicified and sideritized country rock (Pl. VII., Fig. 3).

Pyrite filling the interstices between crystals and grains of quartz is sporadically found in the quartzose veinlets under consideration, and is sharply cut by the veinlets of siderite (Pl. VII., Fig. 4).

The country rock, green slate as well as carbonaceous, is extensively traversed, near the veins, by irregularly crossing veinlets of milky quartz, ranging in width up to 2 cm. or more. The quartzose veinlets containing sporadic cassiterite are also intricately cut by these barren quartz veinlets, as can be revealed under the microscope. In the environs of the Daisen and Daijukô vein groups, this phenomenon is most conspicuous. The veinlets of this category are barren, but contain insignificant quantities of bornite,



chalcopyrite and zineblende in the form of small specks. They correspond probably to the barren quartz of the last stage of mineralization.

## IX. SUMMARY AND CONCLUSIONS.

At the present time, it is generally accepted that tin veins can be deposited from pneumatolytic as well as hydrothermal solutions,<sup>1)</sup> although those of pneumatolytic origin, containing characteristic pneumatolytic minerals such as fluorite, topaz, tourmaline, apatite and other fluorine and boron-bearing minerals, and accompanied by typical pneumatolytic alterations of the country rock, are of common occurrence.

That the veins under consideration were not formed under pure pneumatolytic conditions is indicated by the absence of characteristic pneumatolytic alterations of the wall-rocks. The slaty rocks in which the veins are enclosed are often intensely chloritized, silicified, epidotized and sideritized,<sup>2)</sup> while no characteristic pneumatolytic minerals have been observed in them even under the microscope. These alterations are regarded to be characteristic of hydrothermal processes. Moreover, the veins themselves contain usually more or less siderite and chlorite, as can easily be revealed

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1) The tin veins of hydrothermal origin have been reported by many investigators, the following being some typical examples:—

The tin-bearing veins of the transmetamorphic zone in the Zeehan Field of Tasmania (W. H. Twelvetees and L. K. Ward, "The ore bodies of the Zeehan field," *Tasm. Geol. Surv. Bull.* 8, 1910).

The tin deposits of Mexico, in rhyolite surface flow and accompanied by topaz, quartz, chalcedony and opal, wolframite and bismuth ores (W. R. Ingalls, "The tin deposits of Durango, Mexico," *Trans. Am. I. M. E.*, Vol. 25 (1895), pp. 146-163).

The tin veins of Northern Nevada, containing exclusively wood-tin as tin mineral, in association with opal, chalcedony, lussatite, tridymite, hematite, etc. (A. Knopf, "Wood tin in the Tertiary rhyolite of Northern Nevada," *Ec. Geol.*, Vol. XI, 1916, pp. 652-661).

The cassiterite veins of the Suzuyama mine, Satsuma Province, Japan (T. Katō, loc. cit.).

2) Compare with the altered country rock of the Suzuyama veins (T. Katō, op. cit., p. 149 et seq.).

under the microscope. These minerals occur, though rather sparingly, in ordinary cassiterite veins, and are most abundantly associated with hydrothermal tin veins, siderite, particularly, being of deposition, in most tin veins, in the last stage of pneumatolysis, or in pneumato-hydatogenetic or hydrothermal stages.<sup>1)</sup>

The occurrence of chalcedony, evidently transformed from an opaline silica, as an important gangue-mineral is most instructive. This mineral is an extremely rare associate of tin-stone. Only a few examples of tin veins containing chalcedony have hitherto been reported,<sup>2)</sup> and they all belong to the category formed under hydrothermal or allied conditions. As already fully discussed under the heading of "the deposition of the main cassiterite ore," the presence of chalcedony in the veins under consideration indicates that they were formed under hydrothermal conditions at a temperature below 360° C.

On the other hand, it must be noted that some minerals regarded as common associates of pneumatolytic deposits, such as fluorspar, wolframite and bismuth ores with sporadic microscopic topaz, are present in the veins. These minerals are, of course, of very common occurrence in the deposits formed at high temperatures, but may be deposited either from gaseous solutions or from superheated aqueous solutions containing soluble or gaseous compounds of fluorine, tungsten and bismuth. Typical hydrothermal veins containing scheelite, wolframite, fluorspar, bismuth ores, etc. are numerous even in this country.<sup>3)</sup>

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1) Ferguson and Bateman, loc. cit., p. 225; T. Katō, opt. cit., p. 161.

2) The Mexican deposits (Ingalls, loc. cit.); Those of Northern Nevada (Knopf, loc. cit.) etc.

3) The Kanagasé copper vein of the Ikuno mine, Prov. Tajima, containing scheelite, wolframite, native bismuth, etc.; the gold-silver veins of the Nishizawa mine, Prov. Shimotsuké, containing wolframite, bismuthinite, etc.; the copper veins of the Ashio mine, Prov. Shimotsuké, containing fluorspar, wolframite, apatite, etc.; and others.

The veins of this district are unique in the fact that the ore-bringer for them is a dioritic magma. Considering, however, that acid rocks can be derived from a basic magma by processes of differentiation chiefly due to fractional crystallization and settling<sup>1)</sup> or by the expulsion of the residual fluid magma,<sup>2)</sup> and that an acid differentiation-product with a composition of quartz-monzonite-pegmatite or aplite, akenobeite, is actually found as a small boss in this district, the genetic connection of the veins with the dioritic rocks is highly probable.

Summarizing all that has been stated, the copper-tin veins of the Akénobé district were deposited from hydrothermal solutions,<sup>3)</sup> still containing fair quantities of mineralizers, at gradually decreasing temperatures, chiefly considerably below 360° C. The solutions had naturally a temperature far above the critical point of water (364° C.) and were gaseous in character, after emanation from the consolidating diorite magma. As they ascended through the surrounding slate complex, the rate of the fall of temperature was very rapid, and they soon changed to superheated hydrothermal solutions.

Lastly, the writer frankly states that he is quite in the dark as to whether the stannic oxide first separated from the solutions in the colloid state and subsequently became crystalline, or whether it crystallized directly as cassiterite by chemical reactions between stannic fluoride and other compounds.

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1) N. L. Bowen, "The Later Stages of the Evolution of the Igneous Rocks," Journ. Geol., Vol. XXIII, 1915, Supplement to No. 8, pp. 1-91.

2) A. Harker, "Natural History of Igneous Rocks," p. 323.

3) It should be borne in mind that tin oxide is, according to C. Doelter (Min. petrog. Mitt., Vol. 11, 1890, p. 325), perceptibly soluble in water at 80° C., and more so in the presence of sodium fluoride. This solubility is also indicated by several natural occurrences of tin-stone, as in an opaline deposit from a thermal spring in Selangor, etc. (S. Meunier, Compt. Rend., Vol. 110, 1890, p. 1083; J. H. Collins, Min. Mag., Vol. 4, 1880, pp. 1, 103, and Vol. 5, 1883, p. 121, etc.)

**CONTENTS.**

	Page
I. Introduction .....	1
II. Topography ... ..	3
III. General Geology .....	5
(A) The Paleozoic Formation .....	6
(B) The Mesozoic Formation .....	10
(C) Dioritic Rocks .....	12
(D) Dyke Rocks .....	19
(E) Faults.....	27
IV. The Veins in General ... ..	28
V. The Ore-Bringer.....	36
VI. The Copper-Tin Veins .....	38
(1) The Deposition of the Main Cassiterite Ore .....	40
(2) The Deposition of the Quartzose Wolframite-Cassiterite Ore .....	45
(3) The Deposition of Chalcopyrite .....	48
(4) The Deposition of Zincblende .....	49
(5) The Deposition of Barren Quartz .....	49
VII. The Alteration of the Clay Slate .....	50
(A) Diopsidization of the Slate.....	50
(B) Chloritization of the Slate ... ..	50
(C) Silicification of the Slate.....	51
(D) Epidotization of the Slate .....	52
(E) Sideritization of the Slate ... ..	53
VIII. Quartzose Veinlets cutting the Country Rock Adjacent to the Veins .....	55
IX. Summary and Conclusions .....	57

T. KATŌ:

Copper-Tin Veins of the Akénobé District.

Plate I.

Geological map of the Akénobé vein district


















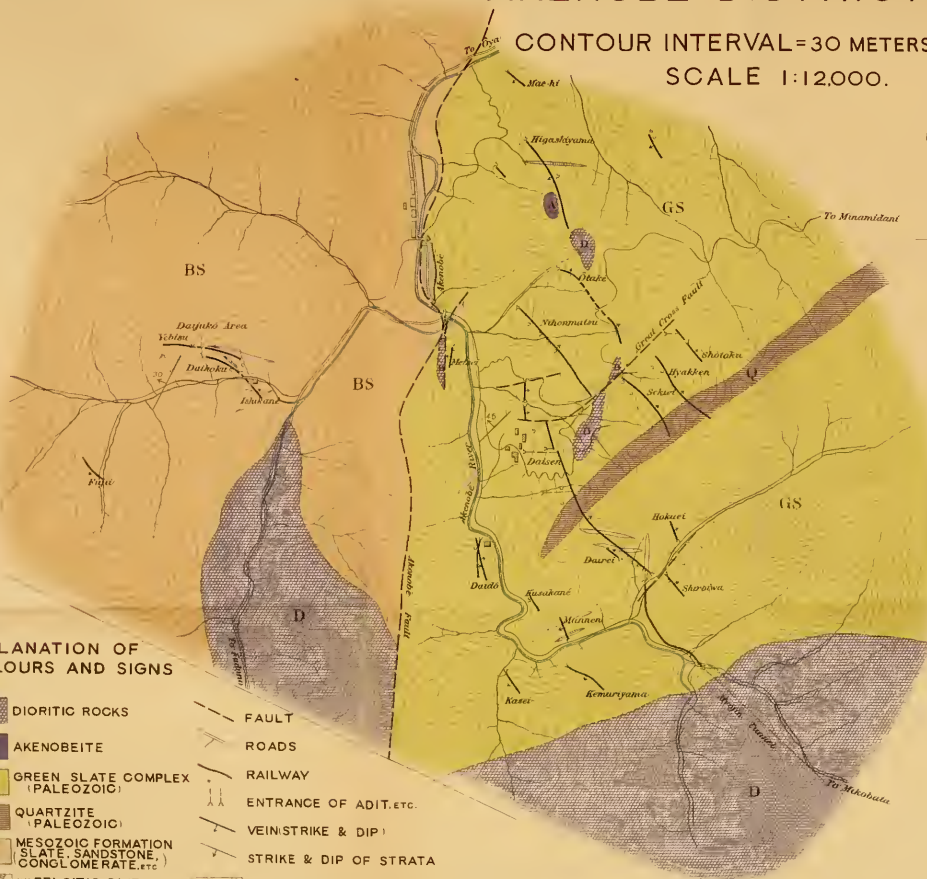
# GEOLOGICAL MAP OF THE AKENOBE DISTRICT.

CONTOUR INTERVAL = 30 METERS.

SCALE 1:12,000.

## EXPLANATION OF COLOURS AND SIGNS

- |   |     |   |   |                        |
|---|-----|---|---|------------------------|
|     | D   | DIORITIC ROCKS  |    | FAULT                  |
|     | A   | AKENOBEITE  |    | ROADS                  |
|     | GS  | GREEN SLATE COMPLEX<br>(PALEOZOIC)                              |    | RAILWAY                |
|    | Q   | QUARTZITE<br>(PALEOZOIC)  |   | ENTRANCE OF ADIT, ETC. |
|   | BS  | MESOZOIC FORMATION<br>(SLATE, SANDSTONE,<br>CONGLOMERATE, ETC.) |  | VEIN, STRIKE & DIP     |
|   | (1) | FELSITIC DIKE   |  | STRIKE & DIP OF STRATA |
|  | (2) | PORPHYRY DIKE   |  | (1) ANDESITE DIKE      |
|   |     |   |  | (2) DIABASE DIKE       |





T. KATŌ:

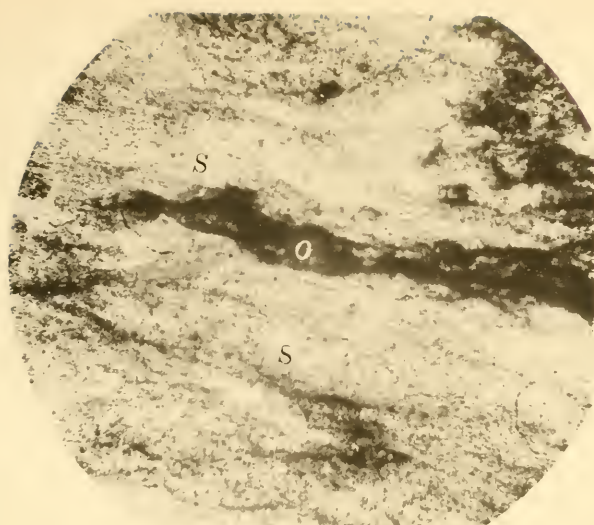
Copper-Tin Veins of the Akénobé District.

Plate II.

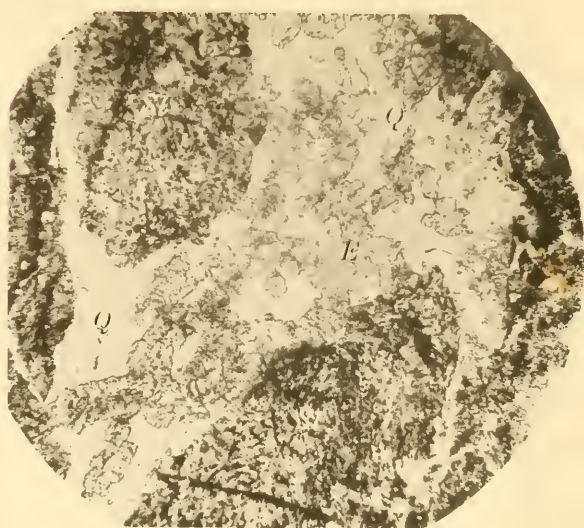
## Explanation of Plate II. (Photomicrographs)

- Fig. 1. Phyllite, exposed near the Minamidani mine. Ordinary light. Magnified 60 diameters. O, aggregate of graphitoid particles; S, micro. grains of quartz mixed with flakes of biotite and sericite, showing schistose structure.
- Fig. 2. Green slate with veinlets of quartz and epidote. Q, quartz; E, epidote; Sl, carbonaceous slate containing abundant chlorite flakes. Ordinary light. Magnified 60 diameters.
- Fig. 3. Silicified slate adjacent to the Daisen vein. Nicols crossed. Magnified 60 diameters. The thoroughly silicified rock, mingled with flakes of chlorite, is intricately traversed by quartz veinlets. Frequently, quartz veinlets grade into highly silicified rock-portions. Q, quartz grains composing veinlets.
- Fig. 4. Chloritized slate (green slate) cut by quartz veinlets. Ordinary light. Magnified 60 diameters. Q, quartz veinlets; Ch, chlorite in aggregate of flakes; S, siliceous slate rich in quartz grains.
- Fig. 5. Uralite-dabase, exposed near the Mannen adit, Akénobé. Ordinary light. Magnified 60 diameters. U, urallite; F, kaolinized feldspar. Note the intersertal (or, in places, ophitic) structure.
- Fig. 6. Quartzite. Loc.—Near the Hyakken mine. Nicols crossed. Magnified 60 diameters. Note that this is composed of inequidimensional quartz grains.

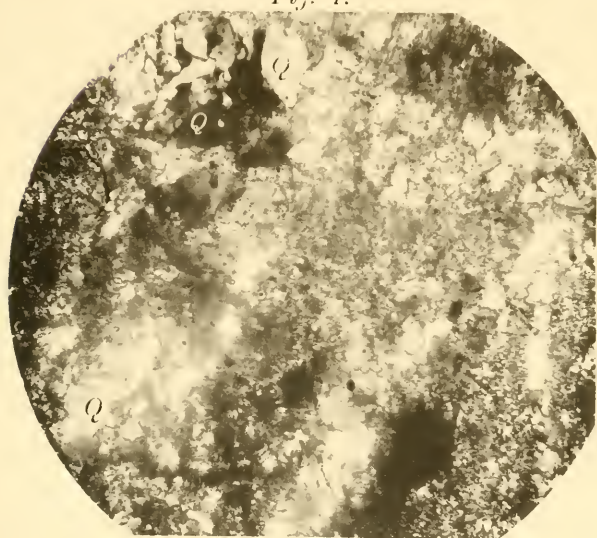




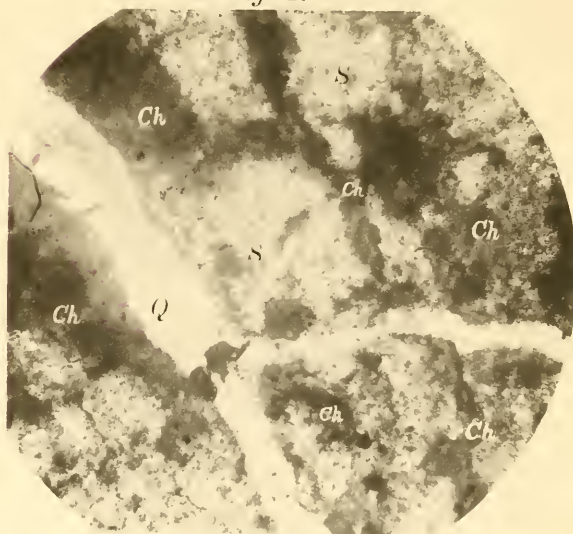
*Fig. 1.*



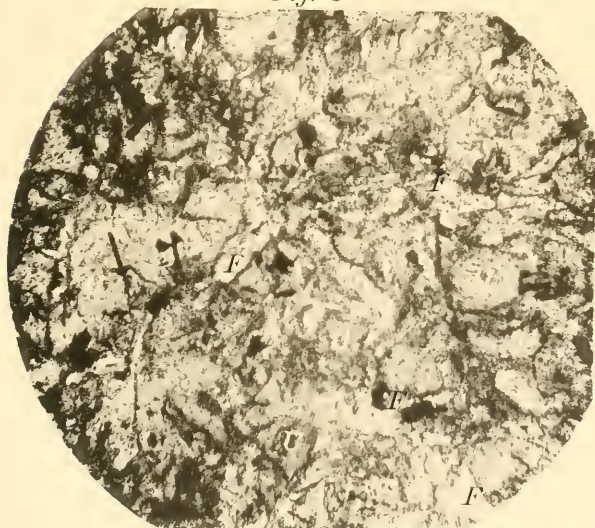
*Fig. 2.*



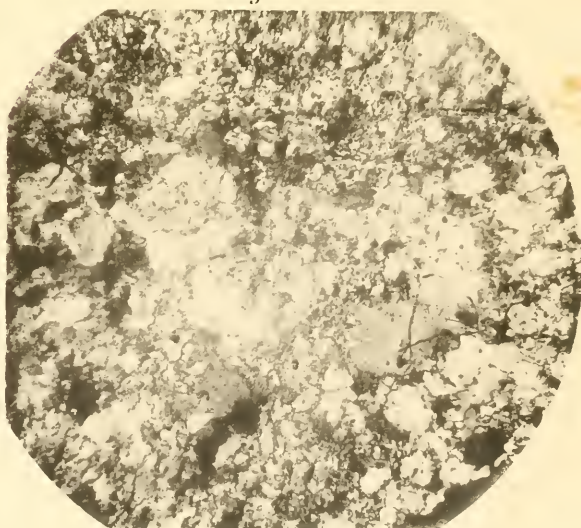
*Fig. 3.*



*Fig. 4.*



*Fig. 5.*



*Fig. 6.*





T. KATŌ:

Copper-Tin Veins of the Akénobé District.

Plate III.

### Explanation of Plate III. (Photomicrographs)

- Fig. 1. Sideritized slate forming the walls of the Daisen vein. Ordinary light. Magnified 60 diameters. S, bleached slate; L, veinlets of limonite altered from siderite; SL, siderite veinlets altered to limonite along the selvages.
- Fig. 2. Diopsidized slate (or diopside-hornfels), collected on the road-side between Akénobé and Fudono Pass. This is a portion of the rock, which is composed almost wholly of minute crystals and grains of diopside (D). Ordinary light. Magnified 60 diameters.
- Fig. 3. Garnetiferous felsite-porphry, forming a dike, found in the Yebisu adit. Ordinary light. Magnified 60 diameters. G, garnet; F, altered feldspar phenocryst.
- Fig. 4. Pyroxene andesite, a dike cutting the Daisen vein. It is usually very altered. Ordinary light. Magnified 60 diameters. F, plagioclase; C, secondary calcite. No pyroxene is shown in this photomicrograph.
- Fig. 5. Diabase, a dike cutting the Daisen vein. White and light-coloured parts are feldspar crystals (F) and altered feldspar; the dark-coloured parts are minute flakes of chlorite. m=Magnetite crystals. Ordinary light. Magnified 50 diameters.

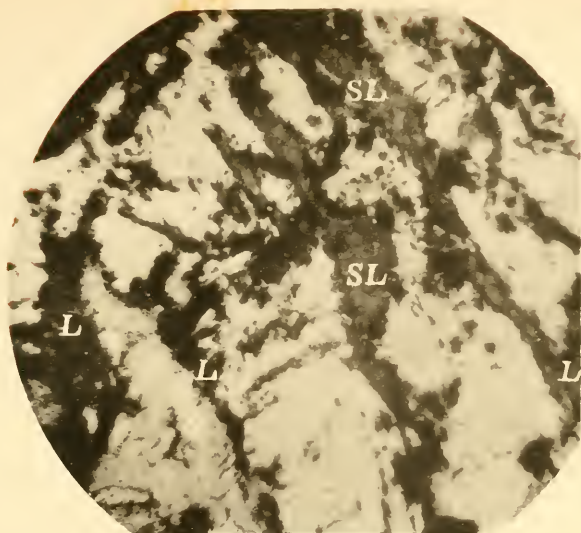


Fig. 1.

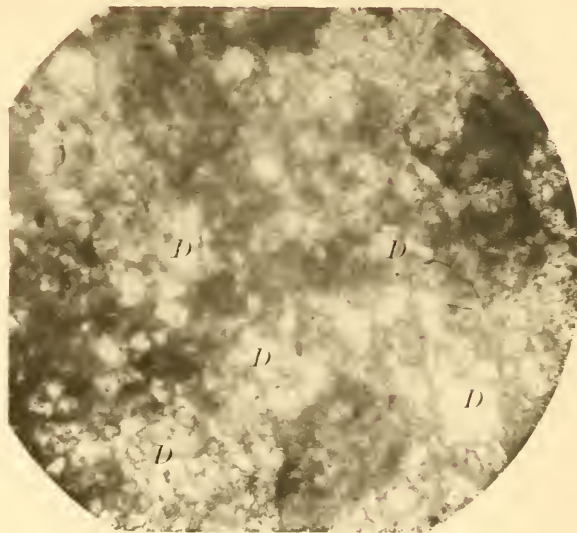


Fig. 2.

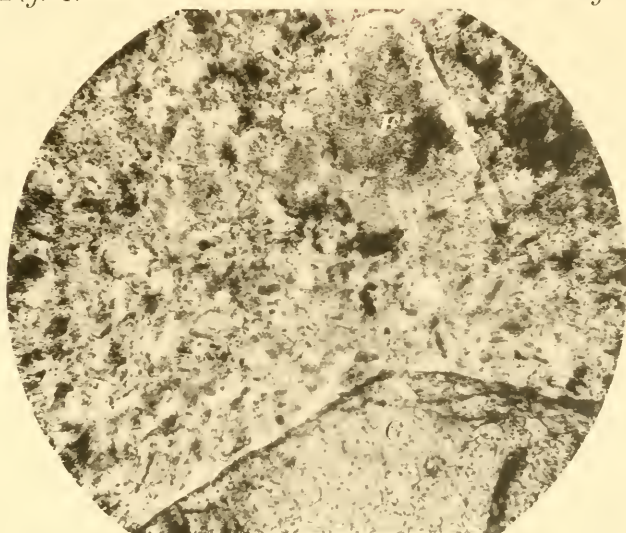


Fig. 3.

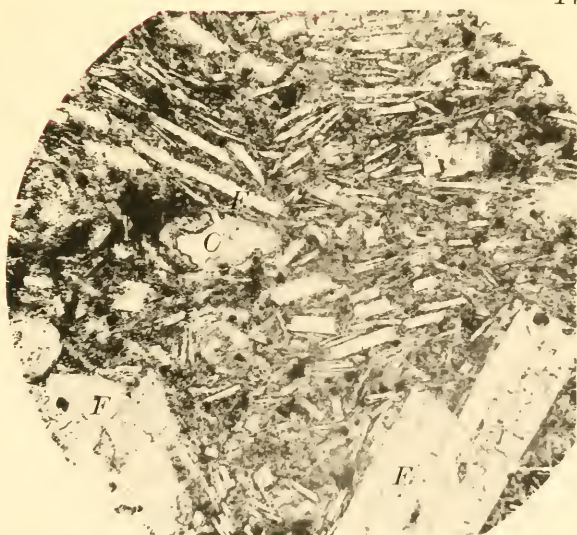


Fig. 4.

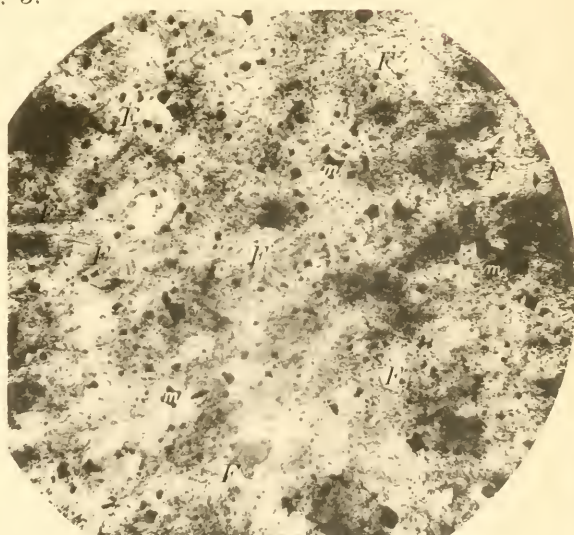


Fig. 5.



T. KATŌ:

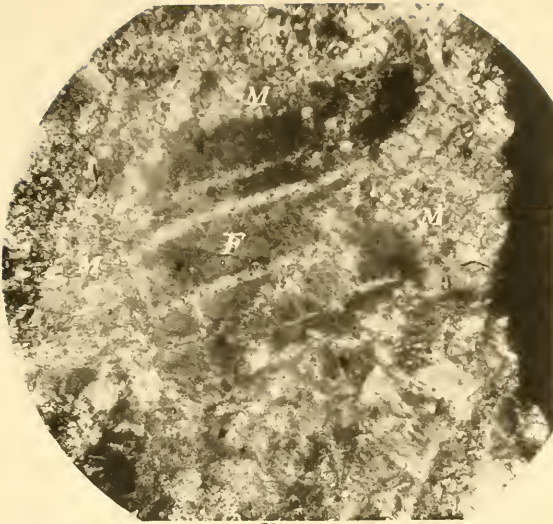
Copper-Tin Veins of the Akénobé District.

Plate IV.

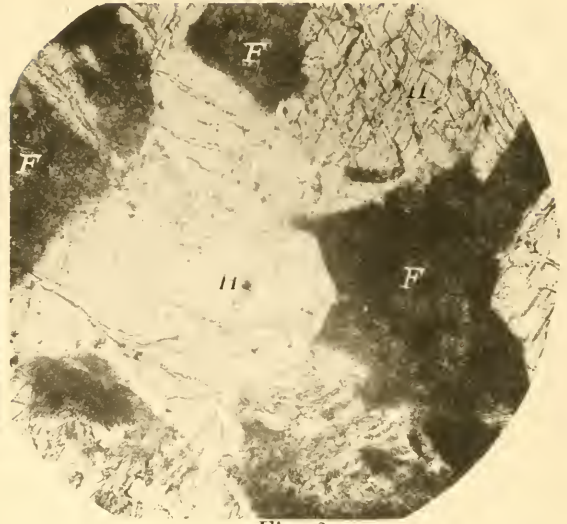
#### Explanation of Plate IV. (Photomicrographs)

- Fig. 1. Diorite mylonite. Loc.—Eastern entrance of the Myōjin tunnel. Nicols crossed. Magnified 60 diameters. F, plagioclase mylonitized along the margin; M, cataclastic grains of plagioclase.
- Fig. 2. Gabbroid diorite. Loc.—Near the entrance of the Sekiei adit. Ordinary light. Magnified 60 diameters. F, entirely kaolinized feldspar; H, hornblende.
- Fig. 3. Akenobeite. Loc.—Higashiyama, Akénobé. Ordinary light. Magnified 60 diameters. F, feldspar (orthoclase and oligoclase); Q, granular quartz.
- Fig. 4. Ditto between crossed nicols.
- Fig. 5. Altered gabbroid diorite, exposed near the entrance of the Sekiei adit. Ordinary light. Magnified 60 diameters. H, hornblende partially altered to a fibrous actinolitic variety; F, entirely kaolinized feldspar with irregular boundaries.
- Fig. 6. Schistose diorite. Loc.—Mikobata Pass. Ordinary light. Magnified 60 diameters. H, hornblende; F, feldspar, granulated and mingled with sericite fibers; P, pyrrhotite.

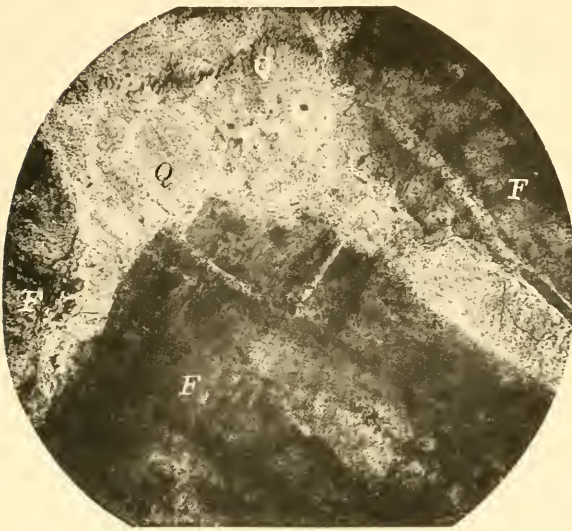




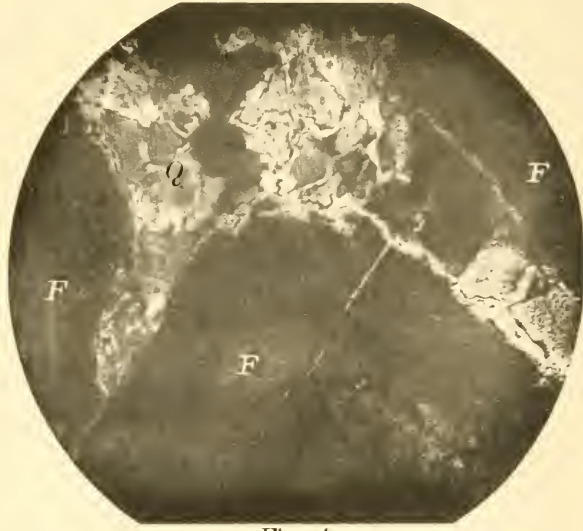
*Fig. 1.*



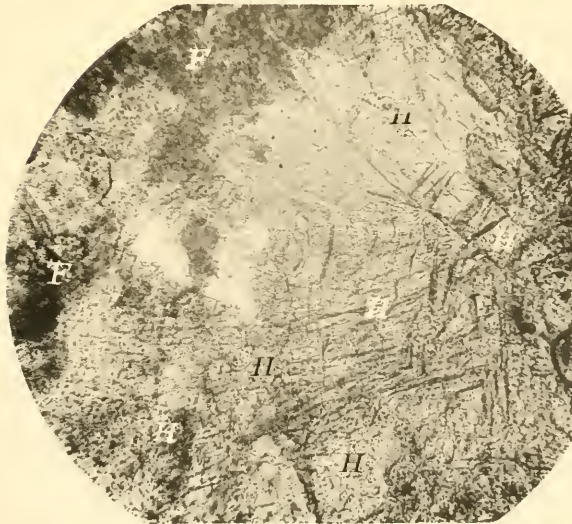
*Fig. 2.*



*Fig. 3.*



*Fig. 4.*



*Fig. 5.*



*Fig. 6.*



T. KATŌ:

Copper-Tin Veins of the Akénobé District.

Plate V.

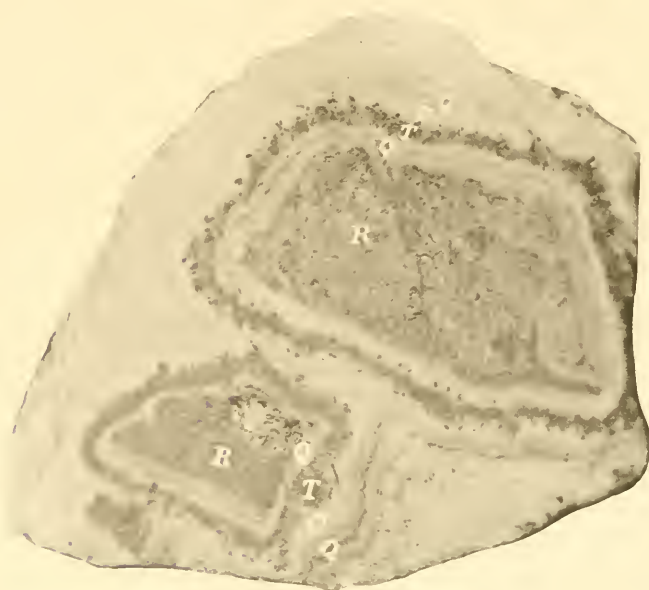
### Explanation of Plate V.

- Fig. 1. Quartzose wolframite-cassiterite ore from the Daisen vein. 1/2 natural size. Q, quartz; *w*, thin plate of wolframite. Cassiterite is enclosed in quartz as microscopic crystals and grains.
- Fig. 2. Ring-ore from the Daisen vein. Natural size. R, silicified or partially sideritized rock-fragment; Q, quartz crust; T, layer rich in cassiterite; C, chalcedony crust. Note a streaky cassiterite zone in the second quartz crust.
- Fig. 3. Another large piece of ring-ore from the Daisen vein. 1/4 natural size. R=ore-ring.

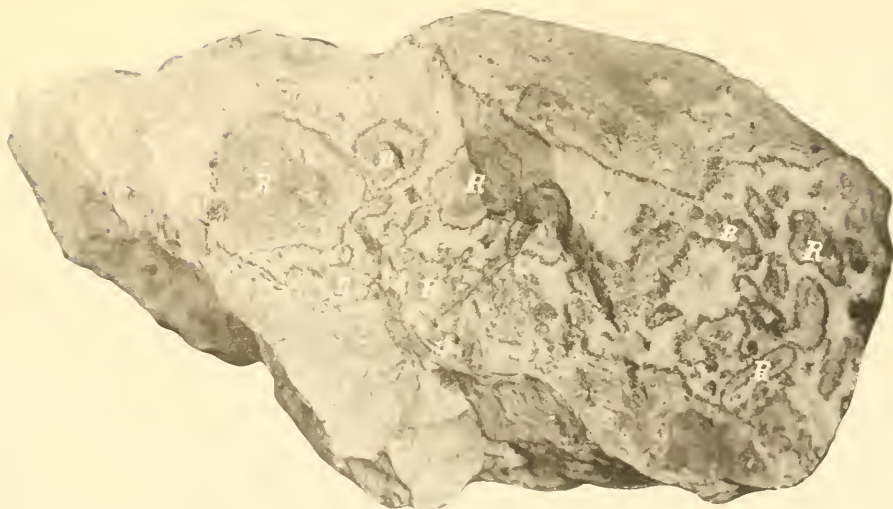




*Fig. 1.*



*Fig. 2.*



*Fig. 3.*





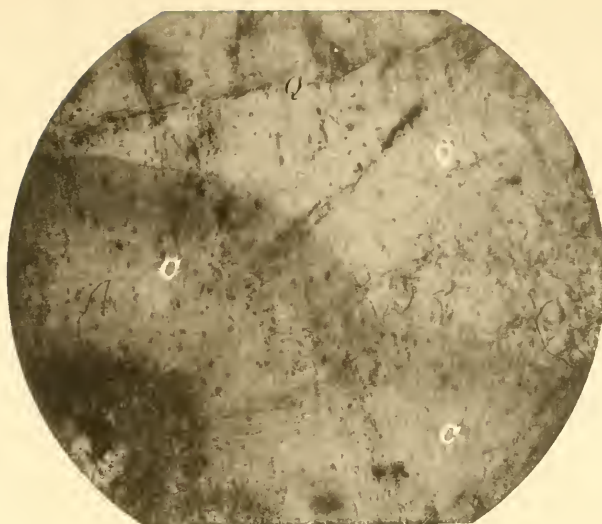
T. KATŌ:

Copper-Tin Veins of the Akénobé District.

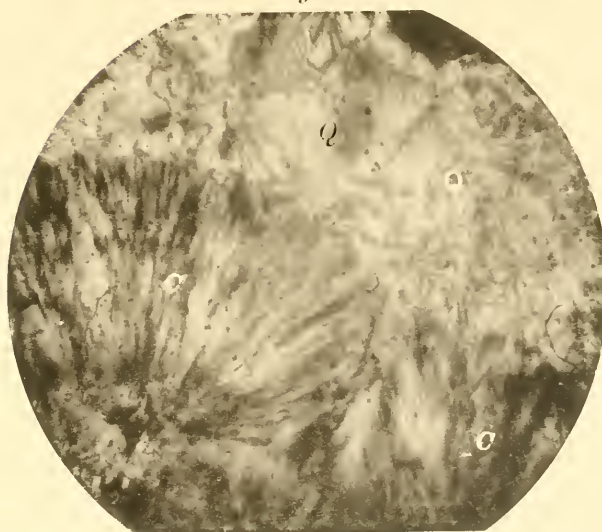
Plate VI.

### **Explanation of Plate VI.** (Photomicrographs)

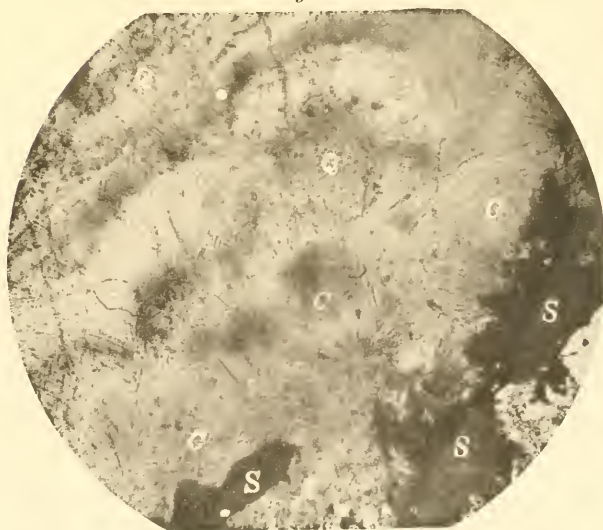
- Fig. 1. Chalcedony crust of the ring-ore from the Daisen vein. Ordinary light. Magnified 70 diameters. Note the radial and fibrous structure of chalcedony.
- Fig. 2. Ditto between crossed nicols, showing more clearly that chalcedony consists of radiating fibers. C, chalcedony; Q, quartz grains of later deposition.
- Fig. 3. Thinner crust of chalcedony in another specimen of ring-ore. S, sulphides, chiefly bornite in association with minute crystals of cassiterite in the earliest crust of quartz; C, chalcedony crust consisting of globular chalcedony; Q, later crust of quartz. Ordinary light. Magnified 50 diameters.



*Fig. 1.*



*Fig. 2.*



*Fig. 3.*



T. KATŌ:

Copper-Tin Veins of the Akénobé District.

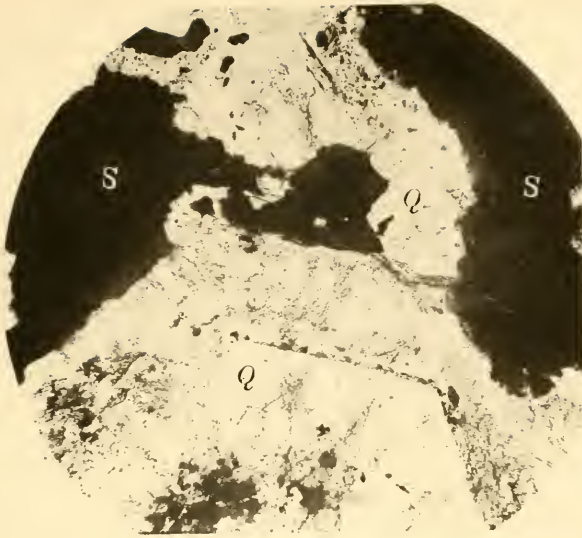
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Plate VII

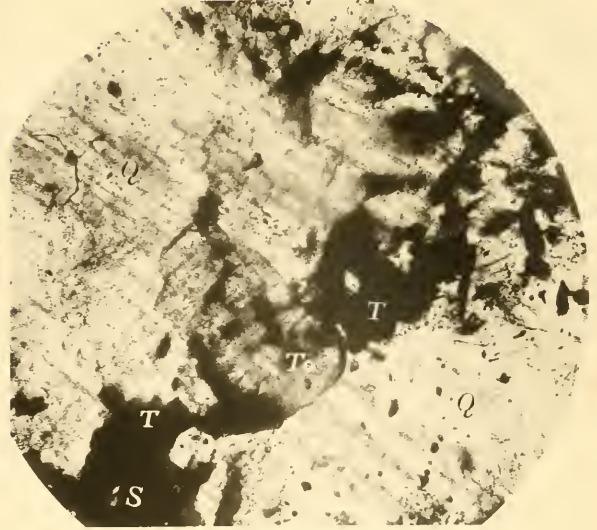
### **Explanation of Plate VII.** (Photomicrographs)

- Figs. 1, 2. Copper-tin ore from the Daisen vein. Ordinary light. Magnified 60 diameters. Q, quartz showing zonal structure; S, chalcopyrite; T, cassiterite in aggregate of minute crystals; To, topaz.
- Fig. 3. Cassiterite-bearing veinlet cutting the wall-rock of the Daisen vein. Ordinary light. Magnified 50 diameters. Sl, more or less silicified slate; T, cassiterite; Q, quartz; C, chlorite; S, siderite veinlet; M, muscovite.
- Fig. 4. Quartz veinlet in the wall-rock of the Daisen vein. Ordinary light. Magnified 50 diameters. Q, quartz; P, pyrite filling the interstices between quartz crystals; S, siderite veinlet cutting the quartz veinlet; Sl, chloritized slate.
- Fig. 5. Wolframite-cassiterite ore from the Daisen vein. Ordinary light. Magnified 50 diameters. Q, quartz; W, wolframite; T, cassiterite crystal; W', alteration-product of wolframite (scheelite).

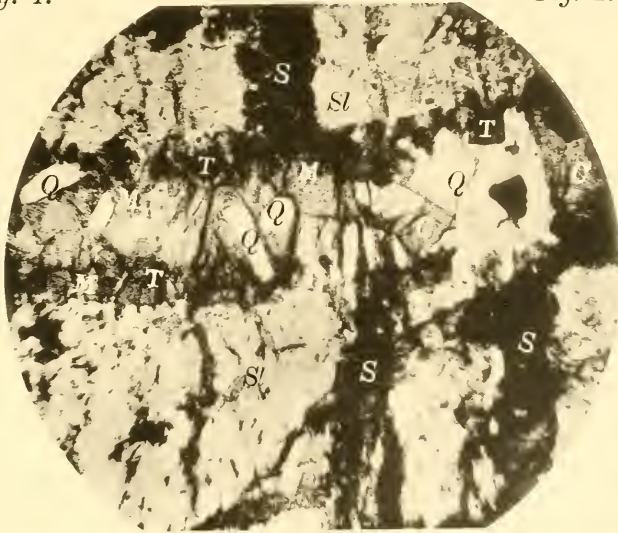




*Fig. 1.*



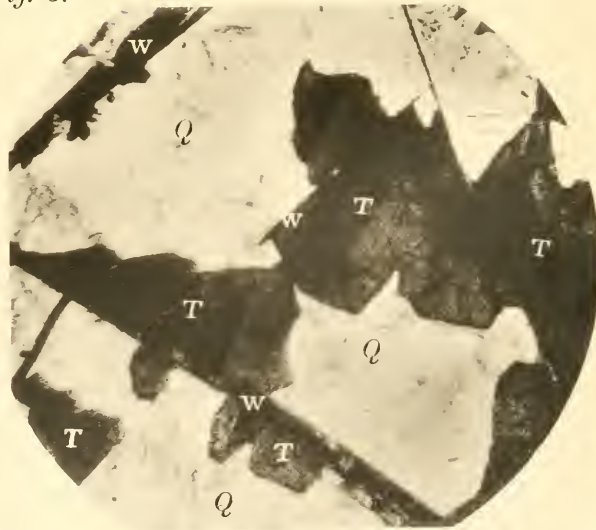
*Fig. 2.*



*Fig. 3.*



*Fig. 4.*



*Fig. 5.*



## Volcano Ôshima, Idzu.

By

Seitarô TSUBOI, *Rigakushi.*

---

*With 6 Plates and 42 Text-figures.*

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### I. Introduction.

The present paper embodies the results of the writer's geologic investigation of the insular volcano Ôshima, in the province of Idzu<sup>1)</sup>, conducted under the auspices of the Earthquake Investigation Committee and of the Imperial University of Tôkyô.

The field observations on which the present work is based were carried out chiefly during two months in the summer of 1916, and supplementarily by making two trips in 1917 and 1918. The laboratory study was performed during the writer's third year course in the Imperial University and in the year after graduation.

In its present state the work is still far from complete, but with the hope of contributing to the vulcanology of Japan the writer has decided to publish the results so far obtained, deferring the making up of deficiencies to a later opportunity.

Here the writer wishes to tender his hearty thanks to Professor B. Kôrô for his great kindness in reviewing the manuscript and for the valuable advice he has constantly given.

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1) 伊豆大島

## Geographic Sketch.

Ôshima in the province of Idzu is the largest member of a

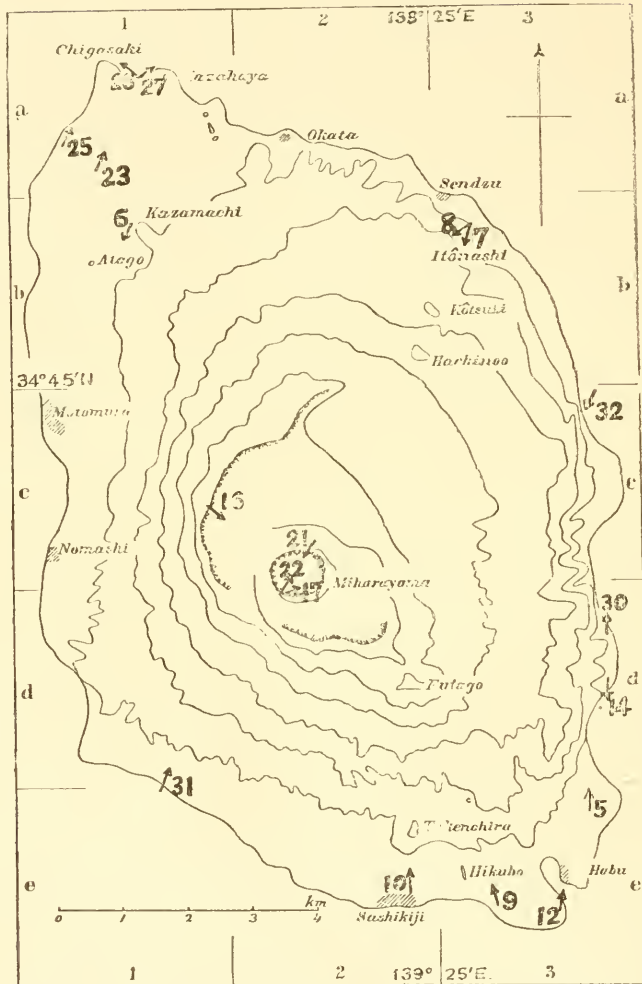


Fig. 1. Index map to scenic illustrations in the text.

In the above index map, the thick numerals indicate text-figure numbers; the arrows indicate the direction in which the scenes given in the text were photographed. The squares, into which the map is virtually divided, will be referred to in the legends of those illustrations by the numerals and letters on its margin.

group of volcanic islands off the Idzu peninsula, commonly called Idzu Shichitô<sup>1)</sup>, or the Seven Idzu Islands, and lies in the sea of Sagami<sup>2)</sup> about 110 *km.* S.S.W. of Tôkyô, extending over 34°40.5'–47'N. lat. and 139°21'–27.5'E. long.

The island is nearly elliptic in shape with a length of about 15 *km.* from N.N.W. to S.S.E., a breadth of about 8.5 *km.* from E.N.E. to W.S.W., and a circumference of about 50 *km.* It has an area of 103.8 sq. *km.* and a volume of 22.6 cub. *km.* (Calculated after Simpson's method.)

The coast line is simple, being indented only at the inlet of Habu<sup>3)</sup> (3e) in the S.S.E. corner. The shore for the most part ends abruptly with precipitous cliffs whose elevations vary up to more than a hundred meters. Around the whole coast there are only two sandy beaches of any extent, one on the west, Yunohama<sup>4)</sup> (1c), and the other on the south, Sonohama<sup>5)</sup> (1e).

The island itself is a gigantic rheuclasmatic volcano elevated 755 *m.* above sea level or about 850 *m.* above the supposed base on the sea floor. It consists of a central homate called Miharayama<sup>6)</sup> (2c), with an active crater at its summit, and a somma-separated by an extensive barren atrio, with such a dreary aspect that it is called "Sabaku"<sup>7)</sup> (the desert) by the islanders.

The ring-wall of the somma is incomplete, lacking its north, eastern and southwestern sides; and from both these gaps barren strips of land extend toward the sea shores.

The outer slopes of the insular volcano vary greatly in different directions. On the western side, the slope is regular and makes a fine concave curve, the inclination being about 25° near the summit and decreasing uniformly toward the foot; on the

1) 伊豆七島

2) 相模灘

3) 波浮

4) 湯ノ濱

5) 砂ノ濱

6) 三原山

7) 沙漠



east it is abnormal, varying from  $15^{\circ}$  to less than  $5^{\circ}$ , and continuing from the top half way down, until, on approaching the shore, it becomes suddenly as steep as  $40^{\circ}$ . The skirt of the mountain is especially well developed on the northwestern side, whereas on the southeast it shows a complex irregular relief. The further continuation (submarine) of the mountain slopes is traceable far along the coast, inclining steeply toward north and east but gently in the opposite directions.

The relief of the cone surface is further diversified by a number of parasitic knobs on its flanks, but as a whole the shape of the island is that of a homate, and its outline viewed from a distance conveys a strong impression of the volcanic origin of the island (Fig. 2).

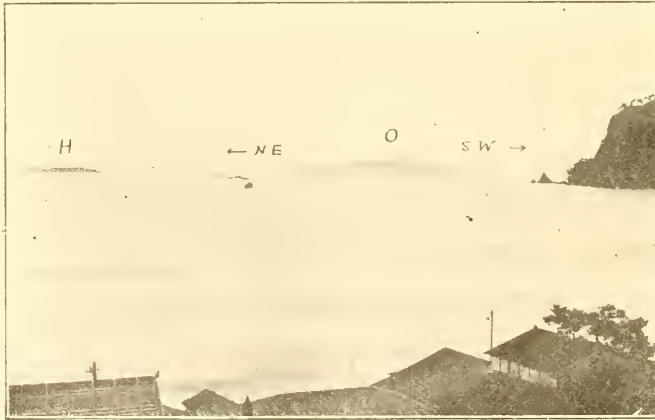


Fig. 2. The island of Ôshima (O), viewed southeastwards from Atami in the Idzu peninsula. Notice the asymmetric form of the volcano.

H...Hatsushima, a small island near Atami.

The climate of the island is equable and rather moist, but the land being built up of loose materials, is dry and lacking in rivers and streams of any importance, as is usual in young volcanoes. Such being the case, rain water is generally used for drinking purposes.



The island was inhabited as early as in the prehistoric stone age by a people belonging to an unknown race whose remains are now found under a lava flow exposed on the precipitous cliff about 0.8 km. to the south of the village of Nomashi<sup>1)</sup> (1c). It is not known when the island became inhabited by the Japanese, but history shews that it was a place of banishment from about the 7th century till the end of the 18th.

At present, the population of about 7400<sup>2)</sup> is distributed in six villages—Motomura (1c), Nomashi (1c), Okata (2a), Sendzu (3a), Sashikiji (2e), and Habu (3e).<sup>3)</sup> In the island peculiar customs are found in coiffures, dress, and the general mode of living, especially of the women.

### Previous Work.

Ôshima has been celebrated in many respects from early times and studied by not a few whose works have been made use of largely.

The first geologist to visit Ôshima (twice in 1877) was EDMUND NAUMANN<sup>4)</sup>. With him were TSUNASHIRÔ WADA<sup>5)</sup> and JOHN MILNE<sup>6)</sup>. The main object of their visit was to see the actual state of the volcanic eruption which had lasted from December 1876 to February 1877, at which time they also made a general geologic survey of the island.

According to NAUMANN, who also gave a brief petrography

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1) 野増

2) The population of the island was 7353 according to the statistics in 1918.

3) 元村 野増 岡田 泉津 差本地 波浮

4) "Die Vulkaninsel Ooshima und ihre jüngste Eruption." *Zeitschrift der Deutschen geologischen Gesellschaft*, Bd. XXIX., S. 364, 1877.

NAUMANN'S opinion was reviewed in the following works by WADA and MILNE:—

5) "Notes on the Volcano Ôshima," *Gakugei Shirin*, Vol. I., No. 1, 1877 (in Japanese).

6) "The Volcanoes of Japan," *Transactions of the Seismological Society of Japan*, Vol. IX., Part. II, 1883; *Geological Magazine*, Decade II, Vol. I., No. 3, 1887.

of the island, the whole history of the volcano may be divided into three periods. (1) The first period is that represented by the crater of Habu<sup>1)</sup> (3e) which he considered to have been submarine till the vent was completely congealed. (2) The second period is marked by the extinction of the Habu crater and the birth of a hypothetical volcano at the northern part of the present Ôshima. The supposed remains of this volcano he considered to have been completely buried later. He assumed the existence of this northern volcanic body to explain the abnormal topography of the island, writing :—

“....Die Convexität des nördlichen Abhanges lässt sich gewiss nicht besser erklären, als durch Annahme einer älteren besonderen Eruptionsaxe für diesen Theil des Berges....”

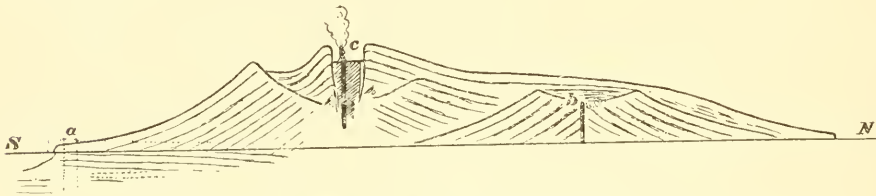


Fig. 3. NAUMANN's ideal profile of Ôshima (N-S).

a....The crater of the first period.      b....The crater of the second period.  
c.... The crater of the third period.

(3) The third period was represented by the present crater of Mihara.<sup>2)</sup>

In 1886, SHÔGO NISHIYAMA<sup>3)</sup> wrote a brief note on the topography of Ôshima and the state of the crater at that time; but the geology of the island was not studied further after NAUMANN's visit until 1895, when NAOMASA YAMASAKI<sup>4)</sup> made his trip.

He noticed the abnormal complex topography of the eastern

1) 波浮 An inlet at the S.S.E. end of the island.

2) 三原

3) "Explanatory Text to the Geologie Sheet of Idzu," 1886 (in Japanese).

4) "Report on the Volcano Ôshima," *Report Earthq. Invest. Com.*, No. 9, pp. 33-53, 1896. (in Japanese).

part of the island in contrast to the regular slope of the western part, and tried to explain this by supposing the existence of older volcanic bodies to the east of the present Ôshima. On this assumption, he divided the whole volcanic history into two stages: the first stage being represented by the hypothetical volcanoes which he considered to have been mostly submerged in water, so that only high parts of the crater wall were above the sea level as in the island of Santorin; the second stage being represented by the present volcanic body which consists of a somma and a central cone.

The harbour of Habu<sup>1)</sup> (3c), according to him, was one of the craters in the first stage, the hills standing to the north of Habu being the remains of the older volcanic bodies.

He moreover recognized the tectonic line running through the island in the direction N.N.W.—S.S.E., along which the central crater and a number of parasitic cones are linearly arranged.

A brief description of the rocks was also given.

It is an interesting fact that some remains of the prehistoric stone age were discovered in 1901, under a lava flow (Pl. VI. BC 3) imbedded in a rugged cliff of Tatsunokuchi<sup>2)</sup> (1d) not far from the village of Nomashi<sup>3)</sup> (1e). YÔNOSUKE ÔTSUKI<sup>4)</sup> and Ryôzô TORII<sup>5)</sup> were sent at the time to examine these and to report on what they saw there.

Next year (1902), DENZÔ SATÔ and NOBUYO FUKUCHI<sup>6)</sup> visited

1) 波浮                      2) 龍ノ口                      3) 野増

4) "Human Remains under a Lava of Ôshima in the Province of Idzu," *Jour. Geol. Soc. Tôkyô*, Vol. VIII., No. 99, 1901 (in Japanese).

5) "Remains of the Stone Age under a Lava of Ôshima in the Province of Idzu," *Jour. Geogr. Tôkyô*, Vol. XIV., Nos. 159 & 160, 1902 (in Japanese); *Jour. Anthropol. Soc. Tôkyô*, Vol. XVII., p. 320, 1902 (in Japanese).

6) "Geological Notes on Ôshima, Idzu," *Jour. Geogr. Tôkyô*, Vol. XIV., Nos. 161 & 162, 1902 (in Japanese).

the island and made some geological observations. They pointed out that the harbour of Habu<sup>1)</sup> (3e), which was thought by the earlier writers to be the crater of an old volcanic body, might be an explosion crater formed at the foot of the main cone of Ôshima; and that Hikubo<sup>2)</sup> (3e), a depression lying to the west of Habu and hemmed in by a horse-shoe shaped wall, might be also of like origin. They further attributed the formation of a great gap on the northeastern side of the ring-wall of the somma to an explosive action.

Cape Chigasaki<sup>3)</sup> (1a), an elevated spot at the northwestern end of the island, was noticed by them for its peculiarity and was considered to be either a parasitic cone or an old volcanic body.

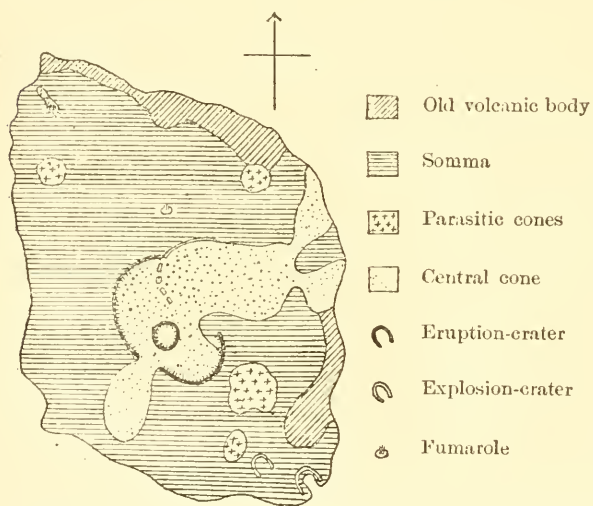


Fig. 4. FUKUCHI's geologic sketch map of Ôshima.

FUKUCHI<sup>4)</sup> visited the island again in 1905, when a destructive earthquake occurred there. A geologic sketch map presented by him with his report shows the existence of old volcanic bodies lying to the north and to the east of the island (Fig. 4).

In 1907, SEIJI NAKAMURA, TORAHIKO TERADA, and DEN'ICHIRO ISHITANI<sup>5)</sup> studied the

1) 波浮 2) ヒクボ 3) 千ヶ崎 or 乳ヶ崎

4) "Geological Observation on the Earthquake of Ôshima in 1905," *Report Earthq. Invest. Com.*, No. 53, p. 87, 1906 (in Japanese).

5) "The Volcano of Ôshima, its Past and Present," *Proceedings of the Tôkyô Mathematico-Physical Society*, Vol. IV., p. 293, 1908; *Jour. Geogr. Tôkyô*, Vol. XX., Nos. 238-239, pp. 682 & 786, 1908 (in Japanese).

physical aspects of the volcano and made a topographic survey of the inside of the crater (Fig. 18, p. 33).

In 1909, IMMANUEL FRIEDLAENDER<sup>1)</sup> spoke of the island as follows:—

(1) The volcanic activity began with the eruption of many craters along the east coast of the present Ôshima. The volcanoes of this stage are too old (probably of the Tertiary period) for the position of their craters to be pointed out now, but the hills in that part consisting of “andesite” must represent the remains of those volcanoes.

(2) In the next stage, the vulcanism was displayed along “the ‘weak line’” running in the direction N.N.W.—S.S.E.: a great cone of the somma was formed very gradually by successive extrusions of “olivine-bearing augite-andesite, very near to basalt”; Habu crater (an explosion-crater) (3e), Futago<sup>2)</sup> (2d), and Itô-nashi<sup>3)</sup> (2b) were then formed on the flanks of the main cone; after that, the huge crater at the top of the present somma was formed either by explosion or by depression, while its northeastern quarter was blown away by explosion; the central cone, Mihara<sup>4)</sup>, as well as the parasitic craters, Hikubo (3e) and Takenohira<sup>5)</sup> (2e), were born in a later stage.

In 1909–10, RYÔICHI ÔHASHI<sup>6)</sup> denied the existence of any old volcanic bodies which all previous writers had supposed to underlie the present volcano.

He considered that the lavas exposed on the cliff opposite to Fudeshima<sup>7)</sup> (3d) and those on the cliff west of Okata<sup>8)</sup> (2a) be-

1) “Ueber einige japanische Vulkane,” *Mitteilungen der Deutschen Gesellschaft für Natur- und Völkerkunde Ostasiens*, Bd. XII, Teil 1, S. 49-59, 1909.

2) 二子      3) 伊東無      4) 三原      5) 岳ノ平

6) “On the Geology of Volcano Ôshima,” *Jour. Geol. Soc. Tôkyô*, Vol. XVI, p. 519, 1909, Vol. XVII, pp. 15, 56, and 96, 1910 (in Japanese).

7) 笠島      8) 岡田



long to the earliest stage. Subsequently, at intervals, repeated extrusion of "black lavas" took place, followed by the ejection of ashes, sands, lapilli, etc. and the extrusion of "gray lavas". In this way a great cone (the present somma) was built up, but a depression took place at its summit and a central cone appeared after repeated eruptions.

He divided the volcanic history into two stages: the *olivine-bearing* stage represented by "Fudeshima lava", "Okata lava", and "black lavas"; and the *olivineless* stage represented by "gray lavas" and the lavas of the central cone.

Very recently the same writer<sup>1)</sup> advanced the view that the area adjacent to the island is rising, or has risen, more rapidly in the east than in the west, thus explaining the asymmetrical form of the volcano,—that the eastern slope is gentler than the western.

During the eruption in 1912–'14, the island was visited by FUSAKICHI ÔMORI<sup>2)</sup>, SEIJI NAKAMURA<sup>3)</sup>, DENZÔ SATÔ<sup>4)</sup>, and YÔZÔ OKAMURA<sup>5)</sup>, who reported on the volcanic eruptions.

KYÔTOKU FUJI<sup>6)</sup> also visited the actual scene of activity and measured the temperature of flowing lava by means of the HOLBORN-KURLBAUM optical pyrometer and found it to be from 995°C. to 1048°C. in the red hot portion, and 857°C. in the dull portion.

1) R. ÔHASHI, "On the Asymmetrical Form of Ôshima," *Jour. Geol. Soc. Tôyôkô*, Vol. XXIV, No. 281, p. 72, 1917 (in Japanese).

2) "Preliminary Report on the Eruption of Volcano Mihara," *Report Earthq. Invest. Com.*, No. 81, 1915 (in Japanese).

3) "The Eruption of Volcano Mihara, Ôshima, Idzu," *Tôyô Gakugei Zasshi*, Nos. 368 & 369, 1912 (in Japanese).

4) "The Present Activity of the Mihara Volcano," *Jour. Geogr. Tôkyô*, No. 239, 1912 (in Japanese).

5) "Report on the Eruption of Volcano Mihara," *Report Geol. Surv. Japan*, No. 48, 1914 (in Japanese).

6) "A Method of Determining the Melting or Solidifying Range of Temperatures of Lava by the Measurement of the Electric Conductivity," *Proceedings of the Tôkyô Mathematico-Physical Society*, 2nd Ser., Vol. VII, No. 14, 1914.



## II. Structure and Morphology.

### Structural Outline.

A general structural idea of the volcano may be formed at a glance. In attempting, however, to discover the inner structure in detail, much difficulty arises as the mountain is covered with ejecta on its sides and is still young in dissection.

Such being the case there seems to be no other way than to conjecture the structure from the exposures on the sea cliffs which afford good natural profiles, as well as from the morphographic features which are so perfectly preserved in their original form, and are consequently so very intimately related with the geologic structure, that they aid us much in the structural investigation.

It is mainly from these two features that the history of the building up of the volcano has been traced, and the results will be stated in the following chapters. Before the detailed descriptions of the structure are given a general summary will be briefly outlined here.

The volcano is a composite stratified one consisting of double homates—a somma and a central one—and is built up of numerous layers, alternately accumulated of rheumatitica and clasmatica of basaltic nature, which have been extruded repeatedly without long intervals of rest between any two successive periods of extrusion.

The somma has several satellitic bodies. On the flanks of the main body of the somma there are many parasitic knobs: Atago<sup>1)</sup> (1b), Kazamachi<sup>2)</sup> (1b), Mitsumine<sup>3)</sup> (1a), on the northwest:

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1) 愛宕

2) 風待

3) 三峯

Hachinoo<sup>1)</sup> (2b), Kôtsuki<sup>2)</sup> (3b), Itônashi<sup>3)</sup> (2b), on the northeast and Futago<sup>4)</sup> (2d), Takenohira<sup>5)</sup> (2e), on the southeast. Two small; explosion-craters, Habu<sup>6)</sup> (3e) and Hikubo<sup>7)</sup> (3e), are at the southeastern foot.

Besides these, there are, along the western half of the northern coast, small igneous bodies strikingly demolished which are considered to have been born in the middle of the volcanic history of the island and are now structurally separated from the main body of the somma.

The top of the somma is truncated with a ring-wall that surrounds a huge oval caldera. The wall is not completely closed but there are two gaps, a greater one on the northeastern and a smaller one on the southwestern side.

The active central homate Miharayama<sup>8)</sup> (2e) stands in the caldera and its volcanic products not only cover the ground within the encircling wall but have also spread down to the sea shore through the gaps in the wall.

The structural scheme above outlined may be shown in a tabular form as follows :—

Volcano Ôshima	{	The main body	{	The somma—A homate truncated at its top with a ring-wall surrounding a caldera, with parasitic cones and explosion-craters on its flanks.
			{	The central cone (Miharayama)—A homate with an active crater, standing in the caldera.
		{		

1) 峰ノ尾

2) コオツキ

3) 伊東無

4) 二子

5) 岳ノ平

6) 波浮

7) ヒクボ

8) 三原山

### Building Materials of the Somma.

The best opportunity for the structural study of the main part of the somma is afforded by the exposures on the sea cliffs. Those observed by the writer are shown in Pl. VI., from which one can see that the somma has been built up by many repeated eruptions. We can enumerate over a hundred lava flows separated by the layers of ejecta—ashes, sands, lapilli, etc. Undoubtedly some of those which appear to be separate flows may represent merely branches of one flow, but considering that what we see on the sea cliffs are only those parts of many lava flows that have been exposed by marine abrasion, their actual total number must be very great.

These lavas are of basic nature, and owing to their fluidity all of them are very thin, seldom exceeding 10 m. and ranging mostly from a few to several meters, sometimes even being less than half a meter in thickness.

Although all of these lavas bear close resemblance to one another in their petrographic characters, yet they may be distinguished into four rock-types.

Petrographic descriptions and intermagmatic relations will be dealt with later (pp. 67—125), but the general characteristics of each type are:—

(1) *Basaltic bandaite almost free from phenocrysts of mafic minerals.*

Lavas of this type predominate and are of the widest distribution.

Phenocrysts of bytownite, varying in amount, are scattered through the aphanitic groundmass, gray to black in colour, consisting of labradorite, augite, magnetite, and a small quantity of

glass. In the great majority of lavas of this type, small olivine phenocrysts are sporadically found in negligible amount, though in some they are lacking.

(2) *Hypersthene-basaltic bandaite.*

Lavas of this type are exposed only on the sea cliff marked *II* (1c) on the geologic map (Pl. V.), to the south of Motomura<sup>1)</sup> (1c), and are intercalated by the lavas of the first type (Pl. VI. BC 2).

This type does not differ from the preceding in its essential characters but is characterized by the presence of hypersthene phenocrysts in moderate quantity.

(3) *Two-pyroxene-basaltic bandaite.*

This is seen only at Gyôja<sup>2)</sup> (3c; marked *III* on the geologic map; Pl. VI. FG 6), in three layers, each about 20 m. in thickness, intercalated by layers of ejecta. This type is marked by the presence of phenocrysts of both hypersthene and augite in moderate quantity, besides those of plagioclase, as well as by the entire absence of olivine crystals.

These lavas appear to have been extruded from a flank opening while the main one was pouring out lavas of the first type.

(4) *Hypersthene-bearing augite-olivine-bytownite-basalt.*

This occurs only at the locality marked *IV* (3d), on the geologic map (Pl. V.), on the east coast (Pl. VI. EF 5). The exposure shows clearly that the lavas of this type were discharged from a local vent during the extrusion of lavas of the first type (p. 77).

The characteristic feature is the presence of olivine and augite crystals in abundance.

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1) 元村

2) 行者

Of the above four types of the somma lavas, the first predominates, being exposed almost at every part of the island, while the other types are very much limited in their occurrence, being found only locally and intercalated with lavas of the first type, and even so only on the sea cliffs and never on the ring-wall of the somma. This suggests that the lavas of the second to fourth types were discharged as the "effluent" flows in DANA's term. Even the lavas of the first type may perhaps not all have come from the summit crater, but some may have been discharged from flank openings.

The question as to how these different rock-types were formed will be discussed later (pp. 118—120).

*Fragmental materials* are by no means less important than lavas in the building up of the somma. According to their origin they may be divided into two kinds: (a) those originating in the magma itself before its consolidation—*juvenile ejecta*, and (b) those coming from the disturbed and shattered portions of the preexisting rocks.

Most of the ejecta are juvenile ejecta (a), and are of all grades in size,—volcanic ashes, sands, lapilli, and bombs.

The blocks belonging to (b) are found imbedded in the layers of volcanic ashes and sands, forming agglomerate beds. Ejecta of various kinds are exposed in alternate layers on the sea cliffs, on the walls of valleys, on road cuttings, and on the crater walls. These appear, so far as observed, to be subaerial deposits, there being no trace of any sorting action by the water on the pieces of ejecta.

Of the various volcanic products, special mention must be made of scoriæ, which are brown to black, consisting almost wholly of glass, and having been formed by the sudden chilling

of the magma. The surface of the lava is often scoriaceous. Some of the scoriaceous lapilli may have originated from the dough in the crater; but another origin is also probable. It is conceivable that as the lava flowed out its surface consolidated while the interior was still in the molten state, so that when the molten pieces were ejected they broke the surficial crust of the lava,—hence the formation of scorïæ. Scorïæ considered to have been formed in this way were often observed, being associated with the lavas or accumulating on them as small spatter cones. Examples of such accumulation of scorïæ are seen at Kagamilhata<sup>1)</sup> (1c) and at Akahage<sup>2)</sup> (1b).

In short, the somma consists of many lavas and ejecta, the result of repeated volcanic actions, which accumulated in alternating layers. The effect of these and later ejections is, that the surface of the ground is so entirely covered that it is impossible to estimate the structure of the core of the volcano and the distribution of each lava flow.

### Steep Slope along the East Coast.

A remarkable feature of the island is a belt of steep slope, about 40° in inclination, along the east coast running in the direction from north to south (Fig. 5). On examining this part it became clear that it does not represent the original slope, since the lavas and ejecta layers are cut by it, but the geologic explanation for this peculiar feature could not be found except by inferences based on its topography.

ÔHASHI<sup>3)</sup> considered this steep slope to be the remains of the old sea cliff formed by marine abrasion. This explanation, however, does not seem to agree with some of the observed facts:

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1) 鏡端

2) 赤禿

3) "On the Geology of Volcano Ôshima," *Jour. Geol. Soc. Tôkyô*, Vol. XVI, 1909 (in Japanese).



(1) the steep slope has been formed only on the east shore and nowhere else, and there is no apparent justification for supposing



Fig. 5. The steep slope along the east coast of the island, viewed northwards from the flat land at the southeast end, consisting of overflowed lavas and ejecta (Fig. 1, 3e).

that this side of the sea coast has been specially subject to wave action; (2) there is no such platform on the sea bottom of the eastern side of the island as would be present if the steep slope in question had been formed by marine abrasion.

To explain these and other observed facts, the writer proposes another origin, which seems to be more probable, i.e., that this steep slope along the east coast of the island was formed by depression of the eastern part of the volcano along a weak line running in N.-S. direction.

As to the time of its formation, it was no doubt before the completion of the development of the somma, since many somma lavas have obviously overflowed on this steep slope. The flat land at the southeastern end of the island is a composite delta consist-

ing of alternate layers of overflowed lavas and ejecta. Pouring out of lavas and ejection of fragments from the local side vents have taken place at several points along the eastern foot of the steep slope so that for the most part these later materials have concealed the materials which constitute the original escarpment surface. These are exposed only at a few places on this steep side under consideration and on the sea cliff opposite to Fudeshima<sup>1)</sup> (3d).

### Vulcanism on the Flanks of the Somma.

**Parasitic Cones.**—On the flanks of the somma, there are a number of small elevations which are considered to be parasitic cones simply from their outer forms. Their morphographic features are:—

	Names of parasitic cones	Elevations above sea level (in m.)	Elevations above the surrounding area (in m.)	Basal extension (in sq. m.)	Inclination of the side-slope
The north-western flank	Atago (愛宕 1b; Fig. 6)	121.5	80	175,000	20°
	Kazamachi (風待 1b)	128	70	283,000	„
	Mitsumine (三峯 1a)				
	{ The south-eastern-most hill	58	20	25,000	„
	{ The middle hill	56	30	25,000	„
	{ The north-western-most hill	43.4	30	18,000	„
The north-eastern flank	Hachinoe (蜂ノ尾 2b; Fig. 7)	419	{ 120 in N. 25 in S.	237,000	„
	Kôtsuki (コオツキ 3b; Fig. 7)	315	{ 65 in N. 29 in S.	138,000	„
	Itônashi (伊東無 2b; Fig. 8)	128	{ 90 in N. 40 in S.	138,000	„
The south-eastern flank	Futago (二子 2d; Fig. 9)	With a double summit 617.9 & 619	{ 250 in S.E. 60 in N.W.	950,000	„
	Takenohira (岳ノ平 2e; Fig. 10)	231.4	160	411,000	20°-23°

Unfortunately, most of these elevations are entirely covered

1) 箆島



Fig. 6. Atago, a parasitic knob on the northwestern flank of the somma, as seen southwestwards from the foot of Kazamachi. (Fig. 1, 1b)



Fig. 7. Hachino (*H*) and Kôtsuki (*K*), parasitic knobs on the northeastern flank of the somma, as seen southwards. *R*. Ring-wall of the somma. (Fig. 1, 3b)

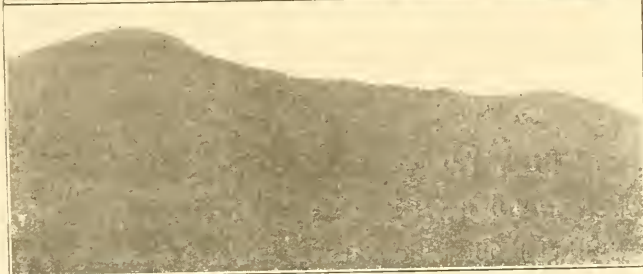


Fig. 8. Itônashi, a parasitic knob on the northeastern flank of the somma, as seen southwestwards. (Fig. 1, 3b)

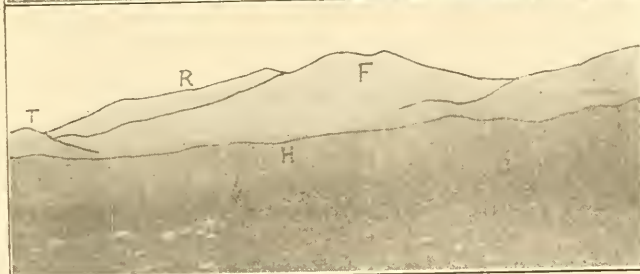


Fig. 9. Futago (*F*), a parasitic knob on the southeastern flank of the somma, as seen northwards, beyond the hemming wall of Hikubo (*H*). *R*. Ring-wall of the somma. *T*. Takenohina. (Fig. 1, 3e)

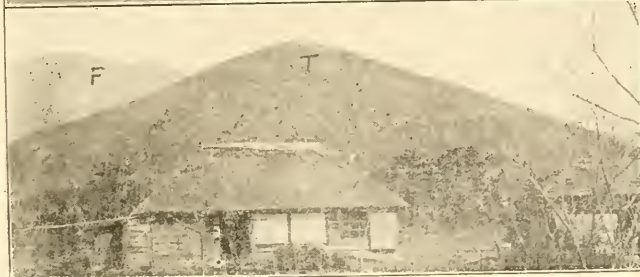


Fig. 10. Takenohina (*T*), a parasitic knob on the southeastern flank of the somma, as seen northwards from the village of Sashikiji. *F*. Futago. (Fig. 1, 2e)

by ejecta of later eruptions and are not yet dissected so that practically nothing is known of their geologic structure and relationship to the main body of the somma. Three of the above, however,—the middle hill of Mitsumine<sup>1)</sup> (1a), Futago<sup>2)</sup> (2d), and Takenohira<sup>3)</sup> (2e)—appear to be built up of scoriæ consisting of glass with some plagioclase phenocrysts.

Other knobs are entirely covered by later ejecta so that it is not evident of what they are composed; but it may not be unreasonable to suppose that they are also constructed of scoriæ seeing they resemble the above three in morphographic features as well as in other respects.

Mention has already been made (pp. 17–18) of the formation of spatter cones by the accumulation of scoriaceous lapilli on the lava surface. It is not impossible that the knobs now under consideration originated in the same way as those spatter cones. But, so far as observed, the lavas are generally on too small a scale to account for such a comparatively large quantity of scoriæ as would be contained in these knobs.

On the other hand, some of the somma lavas are considered to have been discharged as effluent flows from flank openings though the location of these cannot be pointed out at present. It is possible that scoriæ would have accumulated on some of these openings from which the lava flows were extruded. As a matter of fact, it was actually observed in the central crater of Mihara<sup>4)</sup> (2e) on the eruptions in 1876–'77 and in 1912–'14, that a large quantity of scoriæ was spattered out from the vents through which the lavas were issuing.

The parasitic knobs on the flanks of the somma are considered to have been formed in this way by the accumulation of scoriæ

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1) 三峯

2) 二子

3) 岳ノ平

4) 三原

from the side vents which were afterwards buried under later ejecta. Fig. 11 is a diagrammatic representation of the ideal structure of a parasitic cone according to this inference.

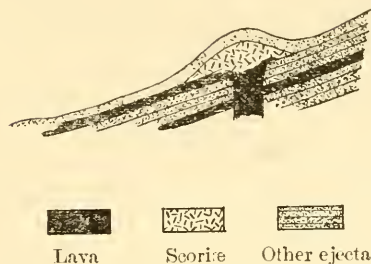


Fig. 11. Diagrammatic representation of the ideal structure of a parasitic cone.

As to the order of the formation of these parasitic cones no reliable statement is possible, since the geologic condition of each of them and their mutual relation are not known. Takenohira (2c) appears, however, to be the most recent, for it is the least covered by later ejecta and its original form is

nearly perfectly preserved with a bowl-shaped depression, to the north of the highest point, which must represent the crater.

The parasitic cones are arranged mainly along the major axis of the island, N.N.W.—S.S.E. This shows that the main flank eruptions took place along the line running in the direction N.N.W.—S.S.E., and that this afforded one of the factors for the extensive development of the skirts of the somma on the northwestern and southeastern sides.

**Explosion-Craters of Phreatic Origin.**—At the southeastern foot of the somma there are two explosion-craters: Habu<sup>1)</sup> (3e) and Hikubo<sup>2)</sup> (3e).

Habu (Figs. 12 & 13) is a harbour at the southeastern end of the island (3e). Nearly circular in shape it is about 300 m. broad, and is connected with the open sea by a narrow channel.

The surrounding wall is precipitous, with an average height of about 50 m. On this wall, lavas and ejecta are exposed in alternate layers as shown in Fig. 13.

1) 波浮

2) ヒクボ





Fig. 12. The harbour of Haba (3e), a phreatic explosion crater viewed northwards. Reference letters, A, B, and C, correspond to those in Fig. 13. (Fig 1, 3e)

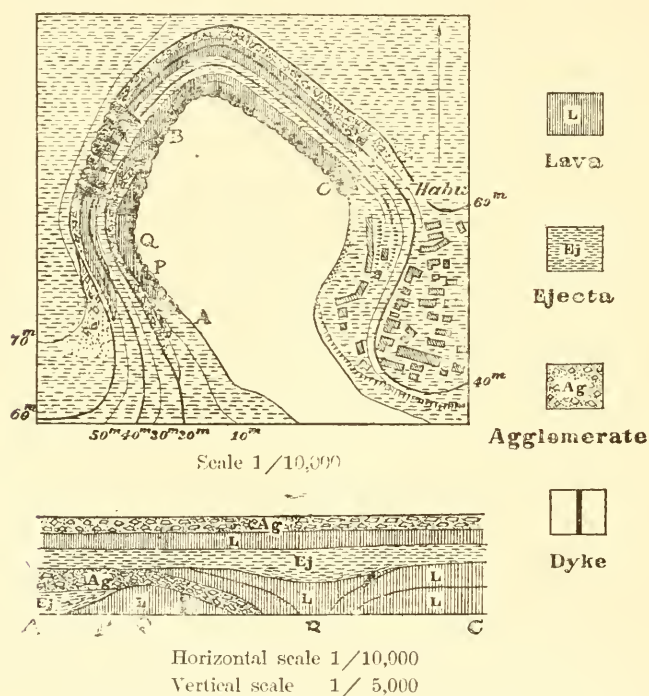


Fig. 13. Haba phreatic explosion-crater (3e).

The harbour was believed by some earlier authors<sup>1)</sup> to be

1) NAUMANN, "Die Vulkaninsel Ooshima und ihre jüngste Eruption," *Zeitschrift der Deutschen geologischen Gesellschaft*, Bd. XXIX., 1877.

YAMASAKI, "Report on the Volcano Ôshima," *Report Enclq. Invest. Com.*, No. 9, 1896 (in Japanese).



the oldest crater in Ôshima, but a close examination does not reveal any evidence for such a supposition. No topographic feature suggests that there was once a volcano having the present harbour as its crater. There are no such magmatic materials as one would expect to have issued from this crater. The lavas and ejecta exposed on the encircling wall are nothing but those of the somma as is clear from their dipping directions (generally toward the southeast), as well as from their petrographic characteristics.

It would seem more probable that this Habu crater was formed by a sudden blowing away of the surficial layers of lavas and ejecta on the flat land at the southeastern foot of the somma (pp. 17-18).

The probability of this inference is further strengthened by the exposures on the crater wall. In Fig. 13 the lava marked *Q* shows a slaggy surface on the left hand side of *P*, while on its opposite side a compact inner part is exposed. The exposure of the compact inner part is attributable to the removal of the slaggy surficial part by explosive action thus leaving the latter on the left side of point *P*.

This explosion was "*phreatic*"<sup>1)</sup> following SUSS's term, being absolutely unaccompanied by any extrusion of incandescent materials, either fluent or pyroclastic. Angular blocks of lava are found scattered in the vicinity of Habu, and if these represent the explosion products of the crater in question, as seems to be highly probable, it follows that the Habu explosion must have taken place at a very late stage of the volcanic history as these blocks of lava are almost free from the covering of any later materials.

According to historic records, Habu harbour was once a

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1) Cited by DALY in his *Igneous Rocks and Their Origin*, 1914.

lake, but was afterwards connected with the open sea owing to the collapse of its southern wall under a seismic tidal wave that attended the earthquake on November 23rd, 1703 (the 12th year of the Genroku era).

Hikubo (3e) lies about 1 *km.* to the west of Habu. This is a spot hemmed in by a horse-shoe shaped wall open to the southeast. This wall, consisting of ejecta and having a height of about 50 *m.*, may also be due to a phreatic explosion. As to the age of its formation, it must be very young, for its original form is preserved without any modification in spite of its easily destructible and loose structure.

If phreatic explosion is due to the heating of surface water by intrusive magma, as is generally believed, the presence of these craters, Habu and Hikubo, indicates that the magmatic intrusion came near the surface in this part of the island.

**The Sea Cliff Opposite to Fudeshima.**<sup>1)</sup>—For about 1,000 *m.* along the coast opposite to Fudeshima (3d) in the south part of the east shore, there is a sea cliff about 170 *m.* high. This is the only cliff that was formed at the foot of that part of the fault escarpment along the east coast (p. 16), which remained uncovered by later volcanic materials. On the southern half of the cliff a thick accumulation of blocks of lava is exposed, with petrographic characters similar to those of the first type of the somma lava (p. 13) but free from olivine; while on its northern half a thick accumulation of red and brown scoriæ belonging to the same petrographic type is visible. Numerous dykes of olivineless basaltic bandaite (sempatie with phenocrysts of basic plagioclase scattered through the compact gray groundmass of comparatively high crystallinity

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1) 筆島

and granularity, consisting of plagioclase, augite, and magnetite) with various widths, ranging from a half to several meters, traverse the cliff in all directions (Pl. VI. EF).



Fig. 14. Fudeshima (F), on the east coast and the 170 m. cliff (C) opposite to it, viewed southwards (Fig. 1, 3d).

L...Flat land consisting of overflowed lavas and ejecta.

**Scoriæ Accumulation on the Southeastern Flank.** — In the southeastern part of the island an accumulation of brown scoriæ are seen. These are exposed on the walls of valleys and of cuttings along roads, being found in alternate layers with the somma lavas, as well as on the surface of the ground. The scoriæ accumulation exposed on the cliff opposite to Fudeshima (p. 24) is an example. That the scoriæ are far more abundantly found in this part than any other shows that these scoriaceous materials were discharged in all probability by local volcanic actions on this part of the flank, though the position of their centres cannot be determined exactly. No doubt these materials were not supplied by one continuous action only, but repeatedly

at intervals. Moreover, as is indicated by their occurrence in alternate layers with the somma lavas, the ejection of these scoriæ and the extrusion of the somma lavas must have succeeded one another.

Summarizing all that has been stated in the present chapter, the volcanic actions have taken place in various parts of the island. They are represented by the extrusion of effluent flows, the ejection of scoriaceous materials, the building of parasitic knobs, the injection of dykes, etc. Above all, the southeastern part of the island was especially subject to volcanic actions: scoriæ were repeatedly ejected in thick accumulation; magmatic intrusion came so near the surface as to cause phreatic explosions; and numerous dykes were intruded, as we see on the sea cliff opposite to Fudeshima.<sup>1)</sup>

### The Caldera.

The somma is truncated at the top with a ring-wall surrounding a huge oval caldera, the major and minor axes of which are 3.2 *km.* from N.N.W. to S.S.E. and 2.5 *km.* from E.N.E. to W.S.W. respectively.

The crest line around the ring-wall is not uniform in its altitude. Its highest point is Shiroishi<sup>2)</sup> (2d) on the southeast, attaining a height of 737 *m.* above sea level. The second highest, Kagamihata<sup>3)</sup> (1c), lies on the northwest (604 *m.*). The rim of the encircling cliff is, as a rule, higher on the east (620–720 *m.*) than on the west (560–600 *m.*) (Fig. 15).

There are two possible explanations for the genesis of the caldera: (1) the blowing away of the apical part of the mountain by explosive action, (2) the depression of the summit.

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1) 筆島

2) 白石

3) 鏡端

If the former were correct we should naturally expect the presence of explosion products above the uppermost layer of lava exposed on the ring-wall encircling the caldera, but on examination no such products are to be found.

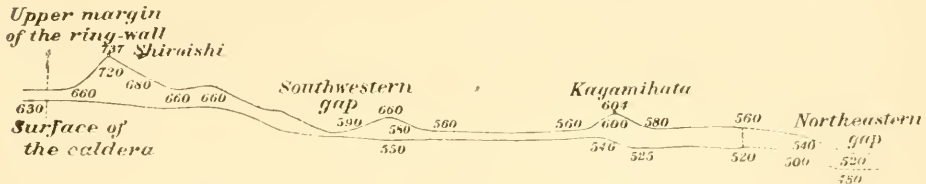


Fig. 15. Elevation of the crest line around the ring-wall.

On the other hand, the latter explanation seems to be preferable as it is highly probable that a hollow space would be formed below consequent on the withdrawal of magma from below the area, and that this hollow would induce the depression of the apical part of the volcano.

Moreover it would seem that the depression must have taken place with its centre somewhat to the west of the very top of the mountain, which supposition agrees with the observed features that (1) the ring-wall is higher on the east than on the west, and that (2) the distance from the margin of the ring-wall to the sea shore is longer on the east than on the west, the main volcano being considered as symmetrical.

There is a great gap in the ring-wall of the somma on its northeastern part, and the north side of this part is hemmed in by an arc-shaped wall.

SATÔ and FUKUCHI<sup>1)</sup> consider this great gap of the somma wall to be the result of an explosion, which formed, at the same time, that part of the wall which extends from due north of the central cone, Mihara,<sup>2)</sup> northeastwards. They based this supposition on

1) "Geological Notes on Ôshima, Idzu," *Jour. Geogr. Tôkyô*, Vol. XIV., 1902 (in Japanese).

2) 三原



a consideration of the morphologic features. NAKAMURA, TERADA, and ISHITANI<sup>1)</sup> also support this view, stating:—

“.....(According to an old record,) detonations like thunder were repeatedly heard in Kyôto in an easterly direction, from October 19th, 1112 till the end of November, and the provincial government in Idzu reported that an eruption had taken place in an island. (The name of the island is not stated.)... Assuming that this eruption took place in Ôshima and the noises caused by it were heard in Kyôto, at a distance of about 180 miles from the supposed origin of the disturbance, we may estimate at least the degree of the eruption in question. By the explosion of Krakatoa, the limit of audibility of the noise was roughly speaking a circle with a radius equal to 2200 miles, when a circular area in radius of about 4 *km.* was blown away. In the eruption of Bandaizan in 1888, the limit of audibility was about 100 miles, and the corresponding linear dimension may be taken as 1 *km.* Without entering into a discussion on the masses exploded off, let us assume that the cube of linear dimensions of the masses blown away is proportional to the square of the distance which sound reaches. Then we obtain from the above data for Krakatoa that in Ôshima a crater with a radius of 0.75 *km.* must have been formed by this explosion, while from those of Bandaizan, we get 1.5 *km.* as the probable radius of the crater.

Now Messrs. SATÔ and FUKUCHI consider the large eastern gap of the old crater wall of the somma to be the result of an explosion, . . . We consider this theory very probable, inasmuch as the theory of the destruction of the crater wall by a lava stream from the central cone is quite untenable, if we remember that a lava stream has generally not such a great velocity or momentum as to sweep before it an obstacle some fifty meters high. The radius of this supposed explosion-crater is estimated to be 1-2 *km.* on the map. Comparing this theory with the estimates given above, we may perhaps propose a hypothesis that the detonations heard in Kyôto in 1112, were due to that explosion which formed the eastern gap in the somma.”

1) “The Volcano of Ôshima, its Past and Present,” *Proceedings of the Tôkyô Mathematical-Physical Society*, Vol. IV, 1908; *Jour. Geogr. Tôkyô*, Vol. XX., No. 233, 1908 (in Japanese).



It seems to the writer, however, that the above is not a positive proof that the gap was formed by an explosion. That the momentum of a lava stream is insufficient to form such a gap as that in question is only suggestive that the gap was formed before the central cone lava flowed down to the east coast. Moreover, it is not sure whether the recorded detonation in 1112 resulted from the eruption in Ôshima or not.

ÔHASHI,<sup>1)</sup> on the other hand, considered that this gap might have been formed by depression, basing his view on the absence of explosion products. But this also is not convincing as the later volcanic materials cover the ground so thickly on the eastern part of the island that the explosion products, if there are any, may well be hidden under these surficial deposits.

To consider the problem geologically is impossible at present as no data are available, so that in the absence of convincing proof that the gap was formed by an explosion, the writer is inclined to agree with ÔHASHI in regarding it as the result of simple depression induced by the formation of the caldera.

### The Central Cone.

The central cone, Miharayama<sup>2)</sup> (2c), stands somewhat to the south of the centre of the caldera. It is a perfectly preserved undissected homate. The highest point lies to the east of the crater-wall and rises 755 m. above sea level, or about 200 m. above the surrounding surface of the atrio. The sides of the homate averaging 20° in slopes are bare of vegetation and are covered by loose sands, lapilli, bombs, and lava-blocks.

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1) "On the Geology of Volcano Ôshima," *Jour. Geol. Soc. Tôkyô*, Vol. XVI, p. 530, 1909 (in Japanese).

2) 三原山



Fig. 16. The central homate, Miharayama, viewed eastwards from the south of Kagamihata (1c). The lava seen on the left side (1a) is that extruded in 1778 (An-ei era). *K*...Kuwajiri, the lowest point of the crater margin. *E*...Loose ejecta of the central cone. (Fig. 1, 1c)

The homate is very simple in its building up, being composed of superfluent lavas and ejecta the alternately accumulated layers of which may be well observed on the inner wall of the summit crater (Fig. 17).

The lavas of the central cone do not differ much from those of the somma, consisting mainly of basic plagioclase, augite, hypersthene (including clino-hypersthene), and magnetite. But *no trace of olivine* has ever been detected, in which point the central cone lavas afford a contrast to the somma lavas, in most of which olivine is meagrely present. Another distinguishing character of the central cone lavas from the somma lavas is that the plagioclase in the groundmass is more calcic in the former than in the latter. Chemically, the central cone lavas are poorer in  $\text{SiO}_2$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{MgO}$ , and  $\text{Na}_2\text{O}$ , but are richer in  $\text{Al}_2\text{O}_3$ ,  $\text{FeO}$ , and  $\text{CaO}$ . As described in the petrography (p. 79), this rock is so peculiar in its composition as to deserve a new name, for which "*Miharaite*," derived from Miharayama, is proposed.

The volcanic products of the central cone, both lavas and ejecta, not only fill the caldera, but are also spread down to the

sea shores through the northeastern and southwestern gaps of the ring-wall of the somma. Especially on the eastern part of the island, the products of the central cone are so distributed over the surface of the somma body as to conceal its original slope.



Fig. 17. The eastern inner wall of the Mihara crater, on which the alternately accumulated layers of lavas (*L*) and ejecta (*E*) are well observed (Fig. 1, 2d).

The summit crater of the central cone is nearly circular, the meridional and equatorial axes being about 700 *m.* and 800 *m.* respectively.

The crater seems to have attained its present size in 1684 according to historic records (p. 55).

It is surrounded by a ridge line as shown in Figs. 18–20 (p. 33), where *a* is the lowest point (665 *m.* above sea level) and *b* the highest (755 *m.*). The ground slopes gently on both sides of this line and the margin of the almost perpendicular cliff of the crater is obtained by descending a few steps toward the inner side. The lowest point of the upper margin of the cliff is Kawajiri<sup>1)</sup> (647 *m.*, *K* in Figs. 18–20) on the north side.

1) 川尻

The feature of the inside of the crater is always changing. It is habitual that when the vulcanism displays its full energy, lava fills the crater, and on declining, the layer of lava depresses more and more due to its own weight, leaving the peripheral parts in the form of terraces.

In 1874, according to MILNE, southwest of the centre of the crater-floor there was a deep hole, from which steam was issuing.

During the eruption of 1876-'77, lava poured out from this hole, and a miniature spatter cone, NAUMANN'S cone (*Nm* in Figs. 18, 19, & 21), was formed on the crater-floor where the hole had previously been. This new cone seems soon to have been blown away on its northwestern side, for when NAUMANN, MILNE, and WADA visited the island during this eruption in January 1877 they found it in this demolished condition. At that time, molten lava is said to have been seen in the summit pit of NAUMANN'S cone.

Nineteen years later, when YAMASAKI observed the Mihara crater (January 1896), he found that NAUMANN'S cone lacked its northern half. There was an intermediate flat stage at the foot of the crater-wall, and at about the centre of this stage (i.e. to the east of NAUMANN'S cone) he found a depression with steep walls, at the bottom of which, in a round hole (vent or crater-pit), red molten lava could be seen. Thus the vent or the crater-pit of NAUMANN'S cone had gradually shifted to the east and had transformed itself into the main pit at the time of YAMASAKI'S visit.

In the summer of 1907, NAKAMURA and his colleagues surveyed in detail the inside of the crater. Fig. 18 is a copy of the map they made. Comparing this map with YAMASAKI'S descriptions we see that in the meantime ( $11\frac{1}{2}$  years) topographic changes had again occurred. As shown in Figs. 18 and 21, NAUMANN'S

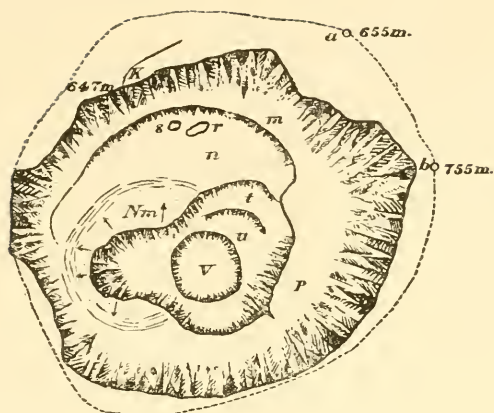


Fig. 18. The state of the inside of the Mihara crater in the summer of 1907. Scale 1/15,000.  
(After NAKAMURA and others.)

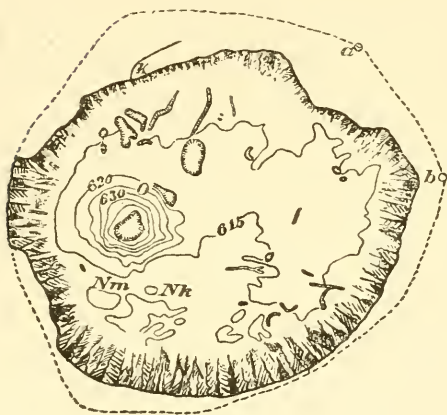


Fig. 19. The state of the inside of the Mihara crater in the beginning of January 1913. Scale 1/15,000.  
(After OKAMURA.)

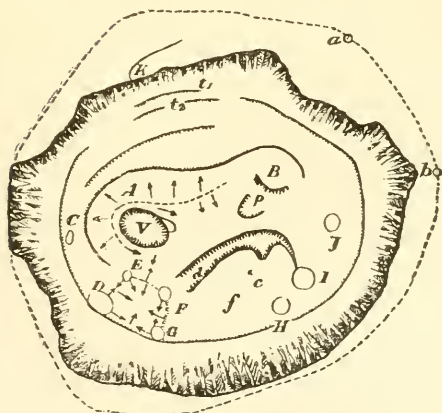


Fig. 20. The state of the inside of the Mihara crater in the summer of 1916. Scale 1/15,000.





Fig. 21. The state of the inside of the Mihara crater in about 1907, looking down southwestwards (Fig. 1, 2c). The reference letters, *Nm*, *V*, *p*, and *m*, correspond to those in Fig. 18.

cone, *Nm*, lacked its eastern side. The central depression at the crater-floor described by YAMASAKI had been transformed into rugged terraces, *t* and *u* in Fig. 18, of which *t* was 20 *m.* lower than the flat part denoted by *n*<sup>1)</sup>, and *u* was 40 *m.* lower than *t*. At the bottom of *u* there was a vent *V*, 160 *m.* across, which was successor to the vent at the time of YAMASAKI's visit. At the foot of the northern wall of the crater, there was a narrow flat strip of land, *m*, about 20 *m.* broad, 500 *m.* in the total length, 30–40 *m.* higher than the bed *n*, and appearing like a gallery. This gallery-like flat strip *m* must correspond to the crater-floor immediately after the eruption in 1876–'77.<sup>2)</sup> From amid the flat bed *n*, two prominences, *r* and *s*, projected abruptly, of which *r* was a mass consisting of lava-blocks with a miniature craterlet at the top, while *s* was a loose pyramidal mass of red brown

1) *n* was about 110 *m.* below the upper margin of the crater-wall and must correspond to the flat stage observed by YAMASAKI.

2) Though nothing is stated about the gallery *m* in YAMASAKI's descriptions, it must have existed at that time.



scoriae the greater portion of which must have since been lost. The area denoted by *p* was covered with dense lava of gigantic dimensions in fantastic forms. The relief of the ground in the crater is shown in the map by means of arrows.

The Meiji-Taishô eruption (1912-'14) began with the outpouring of lava from this vent (*V* in Fig. 18). During this interval, the extrusion of lava took place intermittently five times, of which the second and fourth can be considered as the after-effects of the first and third respectively. In the first period, during March-June 1912, the lava reached a level of 62 *m.* below Kawajiri<sup>1)</sup>, burying half of NAUMANN's cone and forming a new spatter cone, NAKAMURA's cone, somewhat to the southwest of the centre of the crater-floor. The second eruption, in July, was the squeezing out of a new molten lava due to the depression of the lava layer at the crater bottom and resulted in the breaking up of NAKAMURA's cone. In the third activity (September-October 1912), the extrusion of the lava took place from a new vent at the western part of the crater-bottom being accompanied by the formation of a new spatter cone—ÔMORI's cone—around the vent.

Fig. 19 is based on the map published by the Imperial Geological Survey, showing the state of the inside of the crater in the beginning of January 1913, i.e. after the third eruption but before the fourth. Here *Nm* and *Nk* are the apical parts of the two spatter cones, NAUMANN's and NAKAMURA's respectively, freed from the covering of new lava, and *O* is a newly formed (ÔMORI's) cone. The lava constituting the crater-floor is that extruded by the third eruption. The relief at the bottom was as indicated by the contour lines, each representing a vertical distance of 5 *m.*

This feature was modified by the fourth activity in January

1) 川尻 *K* in Figs. 18-20.

1913 which was an extrusion of lava due to the depression of the lava layer at the crater-bottom. The fifth eruption, a magnificent lava outburst in May 1914, strikingly changed the feature of the inside of the crater. The lava came to a level of 14 *m.* below Kawajiri, entirely burying the old cones under newly erupted materials and forming several new ones on the crater-bottom. Cessation of activity was immediately followed by the beginning of the depression of the crater-bottom. After this eruption a very small activity took place in 1915, but this did not much modify the state of the crater.

Fig. 20 is a sketch map based on the writer's eye-measurements in the summer of 1916, showing the feature of the inside of the crater at that time. The bottom of the crater appears, at first sight, to be almost horizontal, being filled with the lavas (now broken into fragmental blocks) of the last eruption. Along the foot of the encircling wall of the crater there is a narrow strip of land (30 *m.* below *K*) which forms two terraces ( $t_1$  and  $t_2$ ) at the foot of Kawajiri. This was formed by the sinking of the ground due to its own weight, soon after the last activity; and  $t_1$  corresponds to the level to which the lava was raised in the last eruption. ÔMORI states that these terraces were in existence on his visit a week after the eruption of May, 1914. The surface of the dislocation wall is vertically grooved and striated. There are, on the crater-bottom, several elevations—spatter cones and their ruins—which are denoted in Fig. 20 by *A*, *B*, *C*, *D*, *E*, *F*, *G*, *H*, *I*, and *J*; of these, the largest two, *A* and *B*, are combined in a long continued hill which is pretty well preserved on the northwestern side but is in a state of collapse on the opposite side. *A* is a spatter cone formed by the last eruption, being elevated about 25 *m.* above the crater-

bottom or about 6 *m.* above Kawajiri (*K*) with a circular pit, about 70 *m.* across and facing to S.S.E., rather large for the size of the cone. At the southeastern foot of the spatter cone, *A*, there is a wide ditch, *d*. The other one of the two conspicuous elevations, *B*, is a dome-shaped lava-mass the top of which is about 4 *m.* below Kawajiri, *K*. At the southern foot of *B* is a hollow, *p*, which is probably the remnant of a pit. The area to the south of the ditch, *d*, shows very irregular relief, the point marked *c*, about 50 *m.* below Kawajiri, being the lowest.



Fig. 22. The inside of the Mihara crater in the summer of 1916, looking down from the southwestern margin of the crater (Fig. 1, 21). The reference letters, *K*, *A*, *V*, and *d*, correspond to those in Fig. 20.

The whole crater is at present a state of deep tranquility. No motion is seen and no sound is heard to cause any uneasiness. Activity is only indicated by fumes with a faint peculiar choking odour of sulphur dioxide, which is the characteristic gas at less active vents according to the law of variation in composition of volcanic gases, first established by SAINTE-CLAIRE DEVILLE, namely, that the nature of the gas evolved depends upon the phase of volcanic activity. The fumes rise calmly at varying places, from

pits and clefts of the elevations on the crater-bottom and from cracks and fissures traversing the lava which fills the crater-floor, depositing sulphur in a yellow crust on any objects with which they may come into contact.

### Small Demolished Igneous Bodies along the Western Half of the Northern Coast.

From the cape of Chigasaki<sup>1)</sup> (1a) at the northwestern end of the island to the west of Okata<sup>2)</sup> (2a), there lies along the sea coast a row of hills elevated from the gentle skirt of the somma. The surface of the hills is covered by the somma ejecta of a comparatively late eruption, but they are underlain by the strikingly destroyed small igneous bodies.



Fig. 23. Chigasaki (C) and Kazahaya (K), remnants of small igneous bodies along the western half of the northern coast, now covered by later volcanic materials of the somma, as seen northwards (Fig. 1, 1a).

The structure of these demolished igneous bodies as well as their geological relation to the main body of the somma may be clearly seen on the sea cliff where marine abrasion has afforded an excellent opportunity to study them (Pl. VI. GA).

Chigasaki (Figs. 23–26) is an elevated spot, 95 m. above sea level, projecting seawards as a cape, and commanding a splen-

1) 千ヶ崎 or 乳ヶ崎

2) 岡田

did view. The peculiar feature of this projection was noticed for

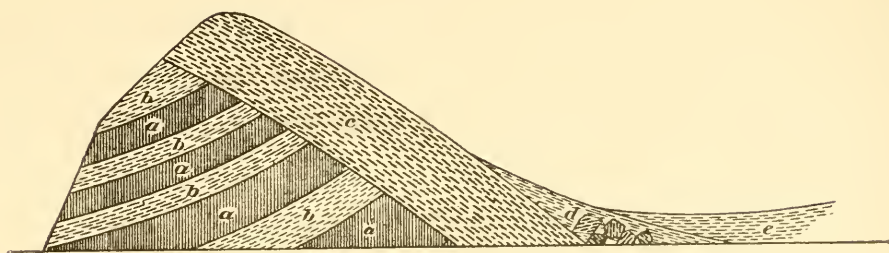


Fig. 24. A diagrammatic sketch showing the structure of Chigasaki.

- a*....Lavas of the igneous body of Chigasaki.
- b* ...Ejecta of the same.
- c*....A layer consisting of small lava-fragments.
- d*....Talus accumulation of the blocks of *c*.
- e* ...Skirt of the somma.

the first time by D. SATÔ<sup>1)</sup> who suggested that it might be either the remains of an old volcanic body or a half-destroyed parasitic cone. ÔHASHI<sup>2)</sup>, on the other hand, is of opinion that it is merely nothing more than a part of the skirt of the somma. FRIEDLAENDER<sup>3)</sup>, on the other hand, considered it as a parasitic cone.

The structure being examined in detail, however, it becomes clear that Chigasaki is neither a mere part of the skirt nor a parasitic cone.

Fig. 24 represents a diagrammatic sketch showing the structure of Chigasaki. The hill is underlain by a demolished igneous body consisting of lavas (*a*) and ejecta (*b*) which dip northwards.

The lava is olivine-rich basaltic with large megaphenocrysts of anorthite, and differs from the most widely distributed somma lava. Over the abraded surface of this igneous body is a layer of

1) "Geological Notes on Ôshima, Idzu," *Jour. Geogr. Tôkyô*, Vol. XIV., No. 162, 1902 (in Japanese).

2) "On the Geology of Volcano Ôshima," *Jour. Geogr. Soc. Tôkyô*, Vol. XVII., No. 196, 1910 (in Japanese).

3) "Über einige japanische Vulkane," *Mitteilungen der Deutschen Gesellschaft für Natur- und Völkerkunde Ostasiens*, Bd. X, Teil 1, 1909.



small lava-fragments (*c*) with a southward dip of  $40^{\circ}$ , in a most pronouncedly discordant relation. The latter is covered at its southern foot with a talus deposit (*d*) formed by the accumulation of blocks of *c* that have fallen from its steep surface. It is over this old talus that the skirt of the main body of the somma (*e*) extends.



Fig. 25. Chigasaki as seen northwards (Fig. 1, 1a).  
The reference letters, *a*, *b*, *c*, *d*, and *e*, correspond to those in Fig. 24.  
*S*... Somma lava of the first type.



Fig. 26. Chigasaki as seen westwards from the north foot of Kazahaya (Fig. 1, 1a).  
The reference letters, *a*, *b*, and *c*, correspond to those in Fig. 24.



From the foregoing it is beyond dispute that what underlies the hill of Chigasaki is a demolished block of a small igneous body structurally independent of the somma body.

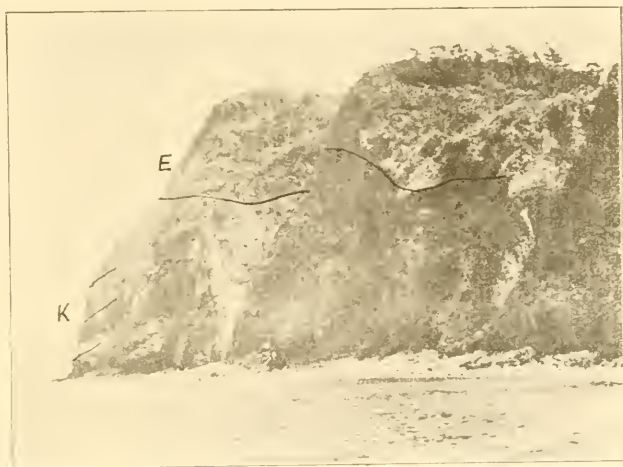


Fig. 27. Kazahaya, a remnant of small igneous body (*K*) covered by later ejected materials (*E*). (Fig. 1, 1a)

The easterly lying Kazahaya<sup>1)</sup> (1a), a hill with a height of 108 m., is also underlain by a demolished igneous body (Fig. 27). It consists of lavas (petrographically somewhat different from those of Chigasaki, but also rich in olivine) and ejecta, dipping also toward the sea, and having a structure like that of Chigasaki (Pl. VI. GA).

To the east of Kazahaya other small igneous bodies of olivine-rich basaltic and doleritic rocks in the form of lavas and intrusives are found (Pl. VI. GA 10—11). They are overlain by layers of contemporaneous ejecta, over the denuded surface of which later materials of the somma are again spread.

Another ruined igneous body (Pl. VI. GA 9) lies to the west of Okata<sup>2)</sup> (2a). This consists of many thin layers of lavas (olivine-bytownite-basalt) and ejecta. What is considered

1) 風早

2) 岡田

to be the centre of the igneous action is exposed on the cliff, the layers of lavas and ejecta inclining outwards (Fig. 28). The whole mass is highly disturbed, being traversed by many fissures, cracks, fractures and joints. Faultings, small in scale (vertical downthrows being  $\frac{1}{3}$  m. in  $f_1$ , 1 m. in  $f_2$  and  $f_3$ , and 5 m. in  $f_4$ ), are also seen on this cliff, always with downthrows on the side of the igneous centre. The formation of these faultings seems to be attributable



Fig. 28. Diagrammatic sketch showing the exposure on the sea cliff to the west of Okata.

*a* ..... Lavas of the ruined igneous body.

*b* ..... Ejecta of the same.

*c* ..... Ejecta of the somma.

$f_1-f_4$ ... Faults.                      (*f*).... Fissure.

to the depression of the layers, due to their own weights, after the igneous agitations were over.<sup>1)</sup> An ejecta bed of the somma body (*c* in Fig. 28) discordantly covers this demolished igneous mass.

From what has been stated in the foregoing pages, it may be claimed that the small demolished igneous bodies along the western half of the northern coast have no direct structural relation to the main body of the volcano Ôshima, and that the materials constituting them were supplied by local vents.

These igneous bodies must have existed, as their structure shows, before the skirt of the main body had developed to its present state, constituting at some time or other islets separated from the main body by the sea. It was not until marine abrasion

1) Depression of lava layers due to their own weight is a phenomenon actually observed in some active volcanoes as Milara (p. 32), Asama (ÔMORI, *Bull. Earthq. Invest. Com.*, Vol. VII, No. 1; *Report Earthq. Invest. Com.*, No. 81), etc.

had destroyed these igneous bodies that these islets were connected with the main body.

As to their probable birth-time, we have no direct evidence, but that such small igneous bodies as these still maintain their existence, though now in a highly demolished condition, in spite of the constant action of the sea, suggests that their birth was not at a very remote date. It would seem to be most reasonable to assume that they were born in the middle of the volcanic history of the main cone, soon after which they ceased to appear.

It is noticeable that the lavas constituting these igneous bodies are all comparatively rich in olivine and pyroxene, in contrast to the common somma lava in which these minerals are either absent or found only in a negligible amount.

Since these olivine-rich lavas are considered to have been discharged from the local vents while the main centre was pouring out olivine-poor lavas, the peculiar character of the former can not be attributed to what is called the magmatic cycle.

It appears likely that these olivine-rich lavas constituting the small igneous bodies were derived from the lower part of a local satellitic magma reservoir. On this supposition all the petrographic facts, especially the occurrence of olivine which the writer believes to be due to gravitational control, seem to be best explained. This point will be discussed fully on pp. 118—119.

The view, that the lavas of the demolished igneous bodies came from a local satellitic magma reservoir, explains the short life of the vents of these bodies. As to the persistence of vents in general, it is believed to be due to the action of "gas-fluxing" or "blow-piping"; so if the vents now in question are

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1) DLAY, "The Nature of Volcanic Action," *Proc. Am. Acad. of Arts and Sciences*, Vol. XLVII, 1911.

supposed to have direct connection with the main magma reservoir, it is difficult to explain why they expired so soon in view of the high probability of a constant action of “gas-fluxing” or “blow-piping.”

### Explanation of the Present Features.

The topography is the end product of structure, process, and stage, as DAVIS says, and all the present features of Ôshima are well explained when they are considered to be the combined results of the structure of the volcano and the agencies at work on it. The surficial agencies that are believed to have been acting on the island are winds, temporary streams caused by cloudbursts, and sea waves. No doubt these agencies must have been operating at every stage of the development of the insular volcano since it came into existence. But, on the other hand, repeated volcanic eruptions depositing juvenile products have covered the effects of these surficial agencies, whereupon the agencies have begun to act anew. Thus the surficial agencies have not yet had a sufficient opportunity to modify greatly the original topographic features dependent on the structure. In the following, an explanation for the more remarkable topographic features will be given :—

#### (I) *The Development of the Mountain Slopes.*

The development of the mountain slopes of Ôshima is not uniform in all directions.

(1) The *western* flank of the somma is very regularly developed showing a gradual slope with decreasing inclination downwards. This may be because no conditions have obstructed the natural development of the mountain slope in this part.

(2) The *northwestern* skirt of the somma is extensively developed with very gentle slope. This is attributable partly to the extrusion of the lavas from flank openings, the more striking of which are indicated by the scoriae accumulations as Atago<sup>1)</sup>, Kazamachi<sup>2)</sup>, etc. (p. 20), and partly to the existence of small igneous bodies (p. 38) along the western half of the northern coast of the present Ôshima, which must have protected the new deposition from marine action, thus affording conditions specially favourable for the extensive development of the skirt.

(3) The *southeastern* part of the island is also extensively developed. This may be due to its having been the scene of frequent volcanic actions (pp. 25-26).

(4) The *eastern* slope of the mountain is abnormal, the gentle slope continuing from the summit to half way and becoming suddenly steep on approaching the sea shore. The profile of the island cut in an E.-W. direction through the centre shows a striking asymmetric form.

This asymmetric form has been noticed by previous writers, and various views have been suggested to explain it. YAMASAKI<sup>3)</sup> tried to explain the abnormal feature of the eastern slope by supposing the existence of some older volcanic bodies in that part (p. 7), while ÔHASHI denied the presence of old volcanic bodies<sup>4)</sup> and attributed the asymmetric form to the tilting of the ground<sup>5)</sup> (p. 10). These are, however, hypotheses for which there is no direct evidence, while the latter may now be proved impossible.

1) 愛宕            2) 風待

3) "Report on the Volcano Ôshima," *Report Earthq. Invest. Com.*, No. 9, 1896 (in Japanese).

4) "On the Geology of Volcano Ôshima," *Jour. Geol. Soc. Tôkyô*, Vol. XVI, pp. 522-524, 1909 (in Japanese).

5) "On the Asymmetrical Form of Ôshima," *Ibid.*, Vol. XXIV, p. 72, 1917 (in Japanese).



It is the writer's belief that the steep slope near the east coast is the remnant of a fault escarpment, as has already been stated (p. 17).

With regard to the cause of the abnormally gentle slope of the eastern flank of the mountain, the present writer differs from previous writers, considering it to be due mainly to an ununiform distribution of the volcanic materials. That this is not improbable may be illustrated thus:—

(a) In the first place, it is a fact often recognized that in some volcanoes<sup>1)</sup>, during their eruption, fine clasmatic ejecta fall more abundantly on the east than on the west, being transported by the upper atmospheric current (at least 4–5 *km.*) which is always travelling eastwards owing to the effect of the rotation of the earth; accordingly it is to be expected that in such volcanoes as Ôshima, where fine clasmatic ejecta take an important part in the building up of the volcano, the asymmetric form of the mountain was originally developed, though the writer has not yet found any direct evidence for this in Ôshima.

(b) As already stated (p. 27), the caldera is considered to have been formed with its centre somewhat to the west of the very top of the somma. The more extensive development of the slope on the east than on the west may be partly attributable to this eccentric depression.

(c) The ring-wall of the somma that surrounds the caldera must have checked the lavas of the central cone from flowing out of the caldera, but there is a great gap in the wall on the east,

1) B. KOTÔ, "The Great Eruption of Sakura-jima in 1914," *Jour. Sci. Coll. Imp. Univ. Tôkyô*, Vol. XXXVIII, Art. 3, p. 125, 1916.

F. ÔMORI, "The Sakura-jima Eruptions and Earthquakes II," *Bull. Imp. Earthq. Invest. Com.*, Vol. VIII, No. 2, p. 115, 1916.

It is said that during the eruption of Asama in May 1911, ashes fell mainly on the east although the surface winds at the time were east or south.



consequently the lavas could flow out through this eastwards, thus affording an additional factor for the abnormal development of the eastern slope.

(d) Another cause for the development of the abnormal topographic features on the eastern flank may be wind action on the dry surface of the caldera. The effects of winds now in operation and actually recognizable are by no means small. The inside of the caldera is thickly covered by loose ejecta (volcanic ashes, sands, lapilli, bombs, lava-blocks, etc.) and by fragmental materials produced by friction or by other destructive actions. The effects of the winds on this dry surface is considerable. The sand-worn blocks, some of which are three faceted in the form of "Dreikanter", lying in the caldera, and various marks on the sandy surface show the abrasive effects of wind-blown sands. These marks indicate the direction of the prevailing wind in the caldera. Feather-like patterns marked on the surface of an aerial volcanic sand bed at the northeastern brim of the central crater show the direction of the wind to be N.E. to E. by N., while the patterns marked on the loose sandy surface at the northeastern part of the caldera by the sorting action of the wind (according to the size of the fragmental materials) show it to be N. by E. to due E. That the finer particles are found accumulated on the lee side of large blocks is an indication of the strength of the winds. The eastern slope of the volcano is thickly covered by sands and lapilli transported by the winds from the caldera through the great eastern gap of the encircling wall.

Although the effect of each of the above may be comparatively slight, yet the writer believes that taken together they may be sufficient to cause the abnormal feature of the eastern slope.

(II) *Surface Sculpture of the Mountain Slopes.*

There is no river in Ôshima, nor is it believed that there ever has been one. Meteoric water in flowing down the natural slopes of the ground as temporary streams (consequent streams) excavated shallow channels or gulches, but later volcanic products often filled these up. Exposures as shown in Fig. 29 are frequently met with on some road cuttings, for example, midway along the road from Nomashi<sup>1)</sup> (1c) to Sembasaki<sup>2)</sup> (1d).

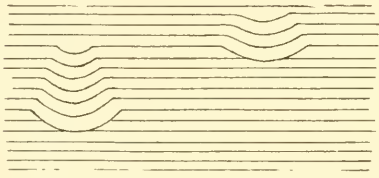


Fig. 29. Ejecta layers showing alternate excavation and deposition.

These reveal the alternately repeated accumulation and dissection.

As a whole, Ôshima is young in dissection, the radial gullies excavated as draining channels being mostly not deep.

In general, the depth of valleys depends on the thickness of the surficial deposit of ejecta overlying the solid lava, since the streams have excavated the ground till the underlying lava surface has become exposed. Most of the valleys in Ôshima (not all) have not yet reached a stage of development where the solid lava is excavated deeply.

Thus different parts of the island are variously dissected. The difference in dissection, however, will be understood when the geologic condition of the island and the surficial agencies acting on it are considered.

In the *northwestern* half of the somma, i.e. on the *northern* and *western* flanks, comparatively shallow radial valleys are rather regularly developed. This is quite natural as the inclination

1) 野増

2) センバ崎

of the outer slopes of the somma is normal in this part and the layers of ejecta covering the solid lavas are comparatively thin.

On the *southeastern* flank, as the original relief is complicated owing to specially frequent volcanic actions on this side (p. 26), the development of the valleys is accordingly irregular. Moreover, as easily dissectible scoriaceous ejecta constitute the ground in this part, temporary streams have excavated it deeply.

The *eastern* slope of the volcano, continuing from the inside of the caldera toward the east coast through the great north-eastern gap of the ring-wall of the somma, is thickly covered by loose sandy materials. There the ground is almost undissected. This is due to the constant levelling action of the western wind in shifting the loose materials.

The part along the east coast of the island is deeply dissected, valleys being sometimes as deep as 200 m. These apparently incomprehensible sculptures may be well understood when the drainage in Ôshima is considered. The water that falls in the caldera, after soaking down through the sands and lapilli, by which the inside of the caldera is loosely covered, till the surface of the underlying lava is reached, runs off the natural slopes; accordingly a larger quantity of water is supplied to the eastern part of the island than to any other, since the ring-wall of the somma is greatly broken on the eastern side and the running down of temporary streams is uninterrupted. Moreover, the slope of the ground is especially steep near the east coast. Both of these conditions would naturally favour a greater dissection here.

### (III) *The Coast.*

The island is constantly subjected to marine erosion at its margins. The waves that dash against the shore break up and

remove the rocks thus forming precipitous cliffs around the island. So the shore of Ôshima ends for the most part abruptly with cliffs. Their elevations vary in different parts. The cliff between Nomashi<sup>1)</sup> (1c) and the cape of Sembasaki<sup>2)</sup> (1d) in the southern part of the western shore, and that opposite to Fudeshima<sup>3)</sup> (3d) in the southeastern part, are especially high, attaining 100 *m.* and 170 *m.* respectively. In other parts, the heights of the cliffs usually vary up to some sixty or seventy meters.

Between Nomashi and Sembasaki the relief of the mountain side as well as that of the sea bottom (notice the 100 fathom line in Fig. 42, p. 140) suggest that this part once projected far into the sea, and that the high cliff may have been formed by the removal of this projecting part by wave erosion.

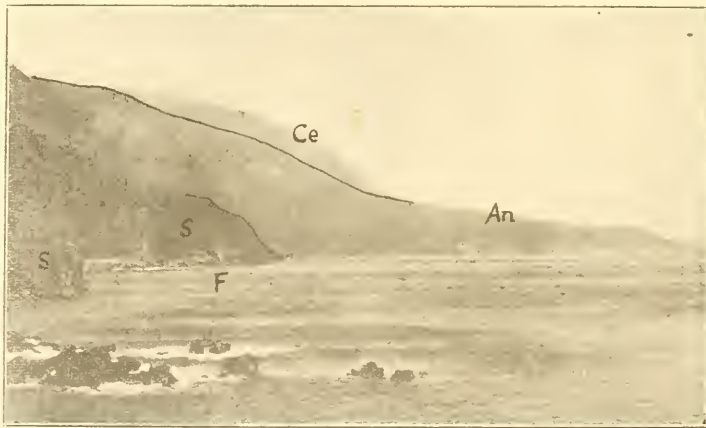


Fig. 30. The northward view of the east coast. *S* ...Somma rocks after the formation of the escarpment along the east coast. *F*...Funô no Taki (a water-fall). *An* ...Central cone lava in 1773. *Ce*...Central cone ejecta. (Fig. 1, 3d)

The formation of the 170 *m.* cliff at the shore opposite to Fudeshima (Fig. 14, p. 25) may be explained by the special conditions of this part. This cliff is at the foot of the steep slope along

1) 野増

2) センバ崎

3) 蜂島

the east coast of the island. As already stated (p. 18), the original surface of this steep slope is covered for the most part by later lavas and ejecta, being protected from marine abrasion, while only at the part where the 170 *m.* cliff is now developed could no covering of later materials be seen. This part, then, must have been subjected to marine action for a long time and the high cliff must have consequently been formed. The steepness of the original slope may also have favoured the development of this high cliff.

The action of the waves has clearly been far more vigorous than the dissecting action of streams, for at every point where a valley ends it hangs high on the sea cliff. The sole, more or less permanent stream in Ôshima near the eastern shore flows down into the sea over a hanging valley in a water-fall called Funô no Taki<sup>1)</sup> (3c; Fig. 30).



Fig. 31. Sanohama, a beach on the southwest coast formed by the accumulation of loose ejecta of the central cone blown down from the caldera. S....Sand-covered southern flank of the somma. C....Old sea cliff showing the stratification of ejecta. (Fig. 1, 1e).

1) 不能ノ瀧



Angular blocks which have fallen from the cliffs are gradually rounded and reduced in size by the action of waves until at last they become sands. Every stage of this course, from large angular blocks to sands, is seen at different parts on the coast of the island. Large angular blocks are found at the foot of every precipitous cliff. Gravel beaches are found at several places, i.e., on the coasts of Chigasaki<sup>1)</sup> (1a), of Nomashi<sup>2)</sup> (1c), of Okata<sup>3)</sup> (2a), etc., while a sandy beach, developed by wave action, is seen on the coast of Motomura<sup>4)</sup> being called Yunohama<sup>5)</sup> (1c).

Besides the above, there are two sand beaches, a small one, Gyôjahama<sup>6)</sup> (3c), on the east coast, and a more extensive one, Sanohama<sup>7)</sup> (1c; Fig. 31), on the southwest coast. But these differ



Fig. 32. Cave of Gyôja on the east coast excavated by wave action. The rock constituting the cliff is somma lava of the third type. (Fig. 1, 3c)

from the above in their origin as they were not formed by the action of the waves, but were developed by the accumulation of sands blown down by the wind from the caldera through the north-

1) 千ヶ崎 or 乳ヶ崎

2) 野増

3) 岡田

4) 元村

5) 湯ノ濱

6) 行者濱

7) 砂ノ濱



eastern and the southwestern gaps of the ring-wall of the somma. The former sea-cliffs, at the base of which the wind-blown sands accumulated, are now inland at distances of some 200–500 m. from the present strands, while from the tops of these cliffs to the inside of the caldera extend barren strips of sandy land.

Other effects of the sea waves are the excavation of caves on the precipices and the formation of sea arches and of detached islands of rocks or stacks. Caves are found at some places, i.e. at Gyôja (3c; Fig. 32), at the cliff opposite to Fudeshima<sup>1)</sup> (3d), and at the cliff to the south of Chigasaki (1a). An example of sea arches is Neji no Iwaya<sup>2)</sup> (3d), on the east coast. Many stacks are seen along the shores of the island. The most conspicuous of these is Fudeshima (3d; Fig. 14, p. 25), on the south part of the east shore.

### III. Volcanic Activity in Historic Times.

ÔMORI<sup>3)</sup> and NAKAMURA<sup>4)</sup> have compiled historic records of the volcanic activity of Ôshima from many scattered and sometimes not readily accessible sources. The following succinct account of the eruptions of Ôshima in historic times is taken mainly from their records.

#### (1) 684 A.D. (天武天皇十三年)

On November 29, 684 (天武天皇十三年甲申年壬辰十月十四日), an eruption took place in Ôshima. This is the first eruption ever

1) 筆島            2) ネヂノ岩屋

3) "Preliminary Report on the Eruption of Volcano Mihara," *Report Earthq. invest. Com.*, No. 81, 1915 (in Japanese).

"Notes on the Volcanic Eruptions in Japan," *Ibid.*, No. 86, 1918 (in Japanese).

4) "History of the Eruptions of Volcano Mihara, Ôshima, Izu," *Ibid.*, No. 79, 1915 (in Japanese).

recorded in our chronology. The land increased by more than 300 *jô* (丈) on the western and northern sides of the island.<sup>1)</sup>

Several authors are of opinion that the area now occupied by the villages of Motomura<sup>2)</sup> (formerly called Niijima<sup>3)</sup>) and Nomashi<sup>4)</sup> was formed by this eruption. For such inference, however, there is no reliable basis, it apparently being merely etymological as Niijima (the former name of Motomura) means "new island" (*nii* new, *jima* island) and Nomashi means "field increase" (*no* field, *mashi* increase).

## (2) 1112 (天永三年)

An eruption of Ôshima?

From November 18, 1112 (天永三年十月二十日) till the end of the next month, detonations like thunder were repeatedly heard in Kyôto from an easterly direction.<sup>5)</sup>

Some authors consider that these were caused by an eruption of Ôshima. It is this eruption that was assumed by NAKAMURA, TERADA, and ISHITANI<sup>6)</sup> to have resulted in the formation of the great gap in the somma wall on its northeastern side (p. 28).

## (3) 1416 (應永廿三年)

On September 2, 1416 (應永廿三年八月二日), an eruption of Ôshima took place.<sup>7)</sup>

## (4) 1421 (應永廿八年)

On May 14, 1421 (應永廿八年四月四日), an eruption of Ôshima

1) 日本書紀

2) 元村

3) 新島

4) 野増

5) 中右記 (A diary written by MUNETADA NAKATOMI [中臣宗忠]).

6) "The Volcano of Ôshima, its Past and Present," *Proceedings of the Tôkyô Mathematical-Physical Society*, Vol. IV., 1908; *Jour. Geogr. Tôkyô*, No. 238, 1908 (in Japanese).

7) 野史 神明鏡

occurred. Noises like thunder were heard in Kamakura<sup>1)</sup> and the sea water became so hot as to cause the death of many fish.<sup>2)</sup>

(5) **1600-1601** (慶長五一六年頃)

**1612-1613** (慶長十七一十八年頃)

**1636-1637** (寛永十三一十四年頃)

In these years, small eruptions took place in Ôshima.<sup>3)</sup>

(6) **1684 1690** (貞享元年一元祿三年)

On March 31, 1684 (貞享元年二月十六日), a violent eruption of Ôshima began, the activity continuing for seven years.<sup>4)</sup> It is said that a crater measuring about 10 *chô* (町) in diameter was formed on the summit of Mihara<sup>5)</sup>. This may probably mean that the central crater of Mihara reached these dimensions at that time.

On April 22, 1684 (貞享元年三月八日), lava flowed out from the foot of Kokamataki,<sup>6)</sup> about 1 *ri* (4 km.) distant to N. 60° E. from the central crater of Mihara, and reached to the sea shore.

(7) **1777-1778** (安永六年一七年)

The eruption of the An-ei era was the most violent one ever recorded in the history of the volcanic activity of Ôshima. Many writings<sup>7)</sup> mention this magnificent outburst.

The first eruption began on August 31, 1777 (安永六年七月二

1) 鎌倉 2) 鎌倉大日記

3) 伊豆七島明細記 (This book tells of an official manuscript of eruptions.)

4) 分類年代記 甘露叢 近世東西略史 常憲院殿御實記 慶安元祿間記 大島山火記 伊豆七島明細記 伊豆海島志 續日本王代一覽 伊豆七島志

5) 三原

6) 小釜瀧 (The locality is not known.)

7) 續日本王代一覽 近世東西略史 後見草 武江年表 大島山火記 伊豆七島明細記 伊豆海島風土記 伊豆海島志 The most authentic and detailed descriptions are found in "Ôshima Sankwaki" (大島山火記), a collection of official reports concerning the eruption of the An-ei era.

十九日). At night, lighting flashes were seen and noises were heard from the summit of the mountain. The land was frequently shaken (probably airquake?), and ashes and Pele's hairs fell throughout the island. On September 29 (八月廿七日), the volcano became quiet, but again broke out in a violent eruption on October 1 (八月廿九日), culminating in the middle of February, 1778 (安永七年正月月中旬), then gradually declining.

On May 27, 1778 (安永七年三月二十二日), lava flowed out from the Mihara crater to the northeast and crept down along Nakanosawa,<sup>1)</sup> reaching a length of 1 *ri* (4 *km.*).

From October, 1778 (安永七年八月下旬), the volcanic activity again became violent, and on November 6 (九月十八日), lava flowed down to the southwest along Akasawa<sup>2)</sup> for 1.5 *ri* (6 *km.*), while on November 15 (九月二十七日), another lava streamed along Gomisawa<sup>3)</sup> for 2 *ri* (8 *km.*) falling into the sea after the "Sawaiian type"<sup>4)</sup> (Fig. 30, p. 50).

On December 18, 1778 (安永七年十一月二十一日), an eruption took place at Sôhajikama.<sup>5)</sup>

The areas covered by the lavas of the An-ei era are indicated on the geologic map (Pl. V.). For the most part they can actually be traced. The locality of Sôhajikama is not known. At the place where a shrine called Hajikama<sup>6)</sup> now stands (3b) there is no trace of any such eruption.

### (8) 1803 (享和三年)

On November 14, 1803 (享和三年十月朔日), an eruption of

1) 中ノ澤

2) 赤澤

3) 工ミ澤

4) B. Kotô. "The Great Eruption of Sakura-jima in 1914," *Jour. Sci. Coll. Imp. Univ. Tôkyô*, Vol. XXXVIII, Art. 3, p. 78, 1916.

5) 宗集地釜

6) 波治釜

Ôshima took place, and on the next day ashes fell in Yedo (Tôkyô).<sup>1)</sup>

(9) 1822 (文政五年)

An eruption of Ôshima took place and ashes fell for two or three years.<sup>2)</sup>

(10) 1846 (弘化三年)

At about this date an eruption of Ôshima took place.<sup>3)</sup>

(11) 1870 (明治三年)

A small eruption of Ôshima lasted for four days.

(12) 1876-1877 (明治九年—十年)

A rather violent eruption took place in 1876-1877, being minutely described by NAUMANN<sup>4)</sup>, MILNE<sup>5)</sup>, and WADA<sup>6)</sup>. The eruption began toward the end of December, 1876 (明治九年). On the 27th, an earthquake (airquake?) occurred, and at night a light on the top of the mountain was seen. The volcanic activity lasted till February 6 (forty days). Lava was poured out in the crater of Mihara<sup>7)</sup> but it did not run over the brim of the crater. The result of this eruption was the formation of a miniature spatter cone, NAUMANN's cone, at the bottom of the Mihara crater.

(13) 1912-1914 (明治四十五年—大正三年)

This eruption lasted for two years and three months, from

1) 續日本王代一覽 泰平年表      2) & 3) 大島明綱記

4) "Die Vulkaninsel Ooshima und ihre jüngste Eruption," *Zeitschrift der Deutschen geologischen Gesellschaft*, Bd. XXIX., 1877.

5) "The Volcanoes of Japan," *Transactions of the Seismological Society of Japan*, Vol. IX., Part II., 1886; *Geological Magazine*, Decade II., Vol. I., No. 5, 1887.

6) "Notes on the Volcano Ôshima," *Takussei Shûrûn*, Vol. I., No. 1, 1877 (in Japanese).

7) 三原

March 1912 (明治四十五年) till May 1914 (大正三年). During this eruption, several experts<sup>1)</sup> visited the island and reported in detail their observations on the actual state of the eruption.

Lavas were extruded in five periods with short intervals of quietude between each two successive periods. They did not run over the brim of the Mihara crater but they changed the state of the inside of the crater.

As a premonitory symptom, slight roarings were frequently heard as early as in 1910.

The first activity began with the pouring out of lava from a vent at the crater bottom in March 1912 and terminated on June 10. During this interval, lava was raised to a level of 62 *m.* below Kawajiri<sup>2)</sup> (the lowest point of the upper margin of the crater wall of Mihara, *K* in Figs. 18–20), half burying NAUMANN'S cone, while a small new spatter cone—NAKAMURA'S cone<sup>3)</sup>—was formed on the surface of the lava layer, somewhat to the south-west of the centre of the crater-bottom.

On July 27, a sudden depression of the consolidated lava layer took place, due to its own weight, leaving the peripheral part in the form of a terrace. This accompanied the breaking up of NAKAMURA'S cone and the squeezing out of a new lava, from July 27 to 29, from the clefts and cracks that traversed the lava layer.

The volcano broke out again in a remarkable eruption on

1) ÔMORI, "Preliminary Report on the Eruption of Volcano Mihara," *Report Earthq. Invest. Com.*, No. 81, 1915 (in Japanese).

NAKAMURA, "The Eruption of Volcano Mihara, Ôshima, Idzu," *Tôkyô Gakugei Zasshi*, Nos. 368 & 369, 1912 (in Japanese).

SATÔ, "The Present Activity of the Mihara Volcano," *Jour. Geogr. Tôkyô*, No. 289, 1912 (in Japanese).

OKAMURA, "Report on the Eruption of Volcano Mihara," *Report Geol. Surv. Japan*, No. 48, 1914 (in Japanese).

2) 川尻            3) 中村山



September 16, 1912 (大正元年), which lasted till October 29 (forty-three days). During this interval the extrusion of lava took place from a vent newly formed at the western part of the crater-bottom. NAKAMURA's cone was buried under the new lava except at its apical part, and a new larger spatter cone—ÔMORI's cone<sup>1)</sup> (O in Fig. 19, p. 33)—was formed on the bottom.

The layer of the lava extruded by the eruption in September—October sank owing to its own weight on January 14, 1913 (大正二年). This was accompanied by a new extrusion of lava which lasted till the 25th.

A magnificent lava outburst that began again on May 15, 1914 (大正三年) reached its climax of intensity during the next three days, thence becoming gradually weaker until on the 21st the continuous lava extrusion ceased, after which erupting intermittently several times in a day it stopped completely within a few days. The lava extruded in this eruption filled up the depressed part formed in January 1913, reaching a level of 14 m. below Kawajiri. Both NAKAMURA's cone and ÔMORI's cone were buried entirely under the newly erupted materials while several new spatter cones were formed on the crater-bottom (Fig. 20, p. 33).

#### (14) 1915 (大正四年)

On about the 10th of October, 1915 a light on the top of the mountain was seen at night. On 14th a small amount of black ash fell in Motomura<sup>2)</sup> (1c), Sanohama<sup>3)</sup> (1e), etc., and at midnight of the 16th strong roarings were heard and airquakes were felt at Motomura. The activity continued till the end of October but ceased without having poured out any lava.<sup>4)</sup>

1) 大森山

2) 元村

3) 砂ノ濱

4) *Tôyô Gakugei Zasshi*, No. 411, 1915 (in Japanese).

#### IV. Petrography.

Ôshima is built up wholly of volcanic rocks. A brief petrographic description of these was given for the first time by NAUMANN<sup>1)</sup> in 1877, then by YAMASAKI<sup>2)</sup> in 1896, and somewhat more in detail by ÔHASHI<sup>3)</sup> in 1910. Specially of the lavas erupted in 1912, brief notes were published by OKAMURA<sup>4)</sup> who visited the scene of the volcanic activity and collected some specimens.

These descriptions, however, are not sufficiently detailed while some are not quite correct; moreover, there is still a wide field open for further study.

Of the previous writers, NAUMANN spoke of sanidine as one of the essential component minerals, citing in his petrographic description the result of the chemical analysis made by KORSCHULT which shews a very high percentage of alkalis (K<sub>2</sub>O 6.28%, Na<sub>2</sub>O 2.02%). This would be quite incomprehensible to any one who examined for himself the rocks of Ôshima, which are, in reality, characterized by specially high lime and extremely low alkalis. Nevertheless, this erroneous result has been reproduced in many later papers by MILNE<sup>5)</sup>, WADA<sup>6)</sup>, NISHIYAMA<sup>7)</sup>, BACHER<sup>8)</sup>, and STARK<sup>9)</sup>, and has become widely known among the petrologists of

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1) "Die Vulkaninsel Oshima und ihre jüngste Eruption," *Zeitschrift der Deutschen geologischen Gesellschaft*, Bd. XXIX., 1877.

2) "Report on the Volcano Ôshima," *Report Earthq. Invest. Com.*, No. 9, 1896. (in Japanese).

3) "On the Geology of Volcano Ôshima," *Jour. Geol. Soc. Tôkyô*, Vol. XVII., 1910 (in Japanese).

4) "Report on the Eruption of Volcano Mihara," *Report Geol. Surv. Japan*, No. 48, 1914 (in Japanese).

5) "Volcanoes of Japan," *Transactions of the Seismological Society of Japan*, Vol. IX., Part II., 1886; *Geological Magazine*, Decade II., Vol. I., No. 5, 1887.

6) "Notes on the Volcano Ôshima," *Gakugei Shirin*, Vol. I., No. 1, 1877 (in Japanese).

7) "Explanatory Text to the Geologic Sheet of Idzu," 1886 (in Japanese).

8) "Über die Laven der kleineren Idzu Inseln," München, 1914.

9) "Petrographische Provinzen," *Fortschritte der Mineralogie, Kristallographie und Petrographie*, Bd. IV., 1914.

the world. Above all, the last two of these authors laid emphasis on the assumed alkaline nature of this rock, considering it as one of the examples of the sporadic occurrence of alkaline rocks in the region of calci-alkaline rocks, a fact which has an important bearing on the current discussion of the genetical relationship of these two branches of igneous rocks.

It is to be regretted that this erroneous report has led some petrologists to such an important but incorrect conclusion as stated above. The writer hopes that the following petrographic descriptions will serve to eliminate this erroneous conception and to add to the meagre petrographic knowledge of the Idzu islands.

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In applying names to our rocks, the definitions given by IDDINGS in his "*Igneous Rocks*," Vol. II. have been followed, partly because of the distinctness of his definitions but mainly because his terms seem to be better fitted to our present case than any others yet proposed.

The rocks of Ôshima may perhaps be called "basalt" according to the loose prevailing nomenclature. In the typical basalt, however, the amount of silica is generally insufficient to form the higher silicates;<sup>1)</sup> while in the main types of our rocks, the silica, in spite of its low percentage, is more than enough to form the highest silicates, leaving some of it still in free state, as indicated by the value of  $k$  in OSANN'S formula ( $k > 1$ ) and by the presence of normative quartz.

What has been just stated is one of the common characteristics of the recent volcanic rocks which are so widely spread through the Japanese archipelago and are commonly called "pyroxene-an-

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1) The type-basalt, calculated by ROBINSON (*U.S. Geol. Surv., Prof. Paper No. 76*, p. 101, 19:3) yields 9.7% of olivine in the norm.

desites." IDDINGS's term "bandaite,"<sup>1)</sup> which includes the quartzose aphanites characterized by normative labradorite, is not only suggestive of the intimate relation of our rocks with "pyroxene-andesites" but also clearly implies the oversaturation of silica with respect to other components.

The application of the term "basalt"<sup>2)</sup> in this paper is restricted only to those rocks so rich in olivine that they are inferred to belong to the perfelic order.

To the rocks of the central cone, a new name "miharaite" has been given on account of their peculiar chemical compositions which will be given later (pp. 87-88).

### Some Specially Devised Petrographic Methods.

For the exact identification of the rock-forming minerals, the writer wished to determine their optical properties as far as circumstances permitted. But, since few of the methods of optical measurement have proved to be applicable owing to the minuteness of the mineral grains, the writer has introduced some specially devised ones, of which brief notes are given in the following:—

**Refractive Indices.**—The refractive indices of the minerals were determined by the BECKE-line method, immersing the mineral grains in liquids of the known indices. With a biaxial mineral, observations were made twice on each grain above a nicol, placing first one of the vibration directions of the mineral grain and then the other parallel to that of the nicol. Repeating the process on a large number of grains of various orientation with different liquids, the highest and the lowest values of the refractive indices,  $\gamma'$  and  $\alpha'$ , were obtained, and then  $\gamma$  and  $\alpha$  were expressed as fol-

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1) *Igneous Rocks*, Vol. II., p. 111, 1913.

2) *Ibid.*, pp. 196-193.

lows:  $\gamma > \gamma'$ ,  $a < a'$ . For the determination of the limiting values of  $\beta$ , the following method was adopted.

The method is based upon the principle that the value of  $\beta$  lies always between the two values of the refractive indices to be observed on a crystal grain of any orientation.

To prove this principle, let  $N_1$  and  $N_2$  be respectively the greater and the smaller normal velocities in any direction  $N$  (Fig. 33) in a crystal, that makes the angles,  $\varphi$  and  $\varphi'$  (where  $\varphi > \varphi'$  without any loss of generality), with the two poles of the optic binormals,  $A$  and  $B$ ; and let  $a$  and  $c$  be respectively the greatest and the smallest principal velocities. Then  $N_1$  and  $N_2$  may be expressed by

$$\left. \begin{aligned} N_1^2 &= \frac{1}{2}(a^2 + c^2) + \frac{1}{2}(a^2 - c^2) \cos(\varphi - \varphi'), \\ N_2^2 &= \frac{1}{2}(a^2 + c^2) + \frac{1}{2}(a^2 - c^2) \cos(\varphi + \varphi'). \end{aligned} \right\} \dots\dots\dots(1)$$

Since the values of the normal velocities are the reciprocals of those of the refractive indices, we have the relations

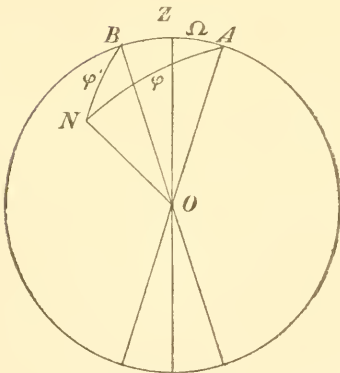


Fig. 33.

$$N_1 = \frac{1}{n_1},$$

$$N_2 = \frac{1}{n_2},$$

$$a = \frac{1}{\alpha},$$

$$c = \frac{1}{\gamma},$$

where  $n_1$  and  $n_2$  are the refractive indices for the faster and the slower waves respectively. From these relations we may transform (1) into

$$\left. \begin{aligned} n_1^2 &= \frac{1}{\frac{1}{2} \left( \frac{1}{a^2} + \frac{1}{\gamma^2} \right) + \frac{1}{2} \left( \frac{1}{a^2} - \frac{1}{\gamma^2} \right) \cos (\varphi - \varphi')}, \\ n_2^2 &= \frac{1}{\frac{1}{2} \left( \frac{1}{a^2} + \frac{1}{\gamma^2} \right) + \frac{1}{2} \left( \frac{1}{a^2} - \frac{1}{\gamma^2} \right) \cos (\varphi + \varphi')} \end{aligned} \right\} \dots\dots\dots (2)$$

Specially when  $N$  coincides with  $B$ , we have

$$\begin{aligned} n_1 &= n_2 = \beta \\ \varphi &= 2\Omega \quad \varphi' = 0^\circ \end{aligned}$$

where  $\Omega$  is the angle between the  $Z$ -axis and one of the optic binormals, (2) may therefore be written as

$$\beta^2 = \frac{1}{\frac{1}{2} \left( \frac{1}{a^2} + \frac{1}{\gamma^2} \right) + \frac{1}{2} \left( \frac{1}{a^2} - \frac{1}{\gamma^2} \right) \cos 2\Omega} \dots\dots\dots (3)$$

Now, as we have in the spherical triangle  $ABN$  (Fig. 33)

$$\varphi - \varphi' \leq 2\Omega \leq \varphi + \varphi'$$

it follows that

$$\cos (\varphi - \varphi') \geq \cos 2\Omega \geq \cos (\varphi + \varphi') \dots\dots\dots (4)$$

for any values of  $\varphi - \varphi'$ ,  $\varphi + \varphi'$ , and  $2\Omega$ , within the limit of  $0^\circ - 180^\circ$ ,<sup>1)</sup> and accordingly from (2), (3), and (4) we have

$$n_1^2 \leq \beta^2 \leq n_2^2.$$

Moreover, as  $n_1$ ,  $n_2$ , and  $\beta$  are positive, we have

$$n_1 \leq \beta \leq n_2 \dots\dots\dots (5)$$

Applying the principle just proved, the limiting values of  $\beta$  were determined as follows:—

The finely crushed fragments of a biaxial mineral were im-

1) We have here no necessity to consider any angles out of this limit.



mersed successively in liquids of different refractive indices and the determination was made on each fragment whether the refractive index of the liquid,  $p$ , was above, below, or lay between, the two values of the refractive indices of the fragment,  $n_1$  and  $n_2$ . Getting the results  $n_1' < n_2' < p'$  in any trial and  $p'' < n_1'' < n_2''$  in another,  $\beta$  was determined from (5) as  $p'' < \beta < p'$ .

In the writer's practical work with refractive liquids, WRIGHT's solutions were used for feldspars, and mixtures of monobromnaphthalene and methyleniodide for the mafic minerals. The indices of refraction of these sets of liquid for sodium light were measured on a refractometer and their constancy was checked from time to time during experiments.

**Optical Orientation.**—Optical orientation of feldspar was determined with the cleavage piece parallel to  $M$  (010)—in which one of the optical binormals is visible through a conoscope—by the following method:—

Examining the section with a conoscope and putting the zero-isogyre parallel to one of the vibration planes of the nicols, the azimuth ( $\varphi$ ) and the central angular distance ( $\rho$ ) of the pole were measured with the screw micrometer ocular,  $\rho$  being reduced from

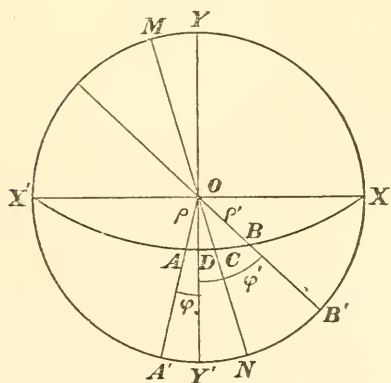


Fig. 34.

the observed linear distance first to the apparent angle by means of MAL-LARD's formula and then to the true angle within the crystal, using the value of  $\beta$  obtained by the method described above. The position of extinction was then observed orthoscopically, and all the data obtained were plotted in stereographic projection as in Fig. 34 where  $O$  is the

centre of the stereogram,  $XX'$  and  $YY'$  the vibration directions of nicols,  $A$  the position of the observed optic axis,  $XAX'$  the great circle representing the optical plane, and  $MN$  the direction of extinction. The straight line  $OA$  was then drawn to cut the stereographic circle at  $A'$ , and taking the point  $B'$  on the same circle so that  $A'N=NB'$  and connecting  $B'$  with  $O$ , the position of the other optic axis  $B$  was determined as the point of intersection of the straight line  $B'O$  with the great circle  $XAX'$  (BIOT-FRESNEL'S law).

The azimuth ( $\varphi'$ ) and the central angular distance ( $\rho'$ ) of the second pole were calculated as follows:—

$$\begin{aligned}\varphi' &= B'ON + Y'ON = A'ON + Y'ON \\ &= \varphi + Y'ON \times 2 \dots \dots \dots (1)\end{aligned}$$

In spherical triangles,  $OAD$  and  $OBD$ , we have the relations:—

$$\sin AD = \sin \varphi \sin \rho \dots \dots \dots (2)$$

$$\tan OD = \cos \varphi \tan \rho \dots \dots \dots (3)$$

$$\cot \rho' = \cos \varphi' \cot OD \dots \dots \dots (4)$$

$$\tan BD = \sin OD \tan \varphi' \dots \dots \dots (5)$$

and from the formulæ (1), (3), and (4), the values of  $\varphi'$  and  $\rho'$  were obtained.

The inclination of the optical plane with respect to the side pinacoid, i. e.  $O.P. \wedge M(010)$ , was determined by subtracting the value of angle  $OD$  from  $90^\circ$ .

**Optic Axial Angle.**<sup>1)</sup>—Calculating the values of  $AD$  and  $BD$  with the formulæ (2), (3), and (5), the optic axial angle was determined ( $AD+BD$ ).

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1) S. Tsuboi, "On the Methods of Measurement of the Optic Axial Angle of a Mineral in Rock Slices," *Jour. Geol. Soc. Tôkyô*, Vol. XXIV., p. 149, 1917 (in Japanese).

### Special Descriptions.

Special descriptions of the rocks of Ôshima will be given below in the following order:—

(A) Lavas of the Somma.

- 1) Basaltic bandaite almost free from phenocrysts of mafic minerals.
- 2) Hypersthene-basaltic bandaite.
- 3) Two-pyroxene-basaltic bandaite.
- 4) Hypersthene-bearing augite-olivine-bytownite-basalt.

(B) Lavas of the Central Cone.

- 5) Miharaite.

(C) Rocks constituting the Demolished Igneous Bodies along the Western Half of the Northern Coast.

- 6) Two-pyroxene-olivine-anorthite-basalt.
- 7) Olivine-bytownite-basalt (*a*).
- 8) Olivine-bytownite-dolerite.
- 9) Olivine-bytownite-basalt (*β*).

(D) Rocks occurring as Dykes.

- 10) Olivineless-basaltic bandaite (*a*).
- 11) Olivineless-basaltic bandaite (*β*).

(E) Ejecta.

- 12) Ashes, Sands, Lapilli, and Bombs.
- 13) Micro-allivalite.
- 14) Augite-micro-diorite.

### (A) *Lavas of the Somma.*

- 1) Basaltic bandaite almost free from phenocrysts of mafic minerals. (The first type of the somma lava.) (Pl. I. Figs. 1-5.)

This type contains the lavas of more or less wide latitude. The characteristic feature which distinguishes this from the others

is meagreness of phenocrysts of mafic minerals.

**Mode of Occurrence.**—The somma lavas of this type are of the widest distribution. They are found through all parts of the island in numerous flows, both superfluent and effluent, alternated by layers of clasmatic materials and constitute the main part of the somma. The best exposures of these lavas are met with on the precipitous cliffs that surround the island (Pl. VI.) and on the ring-wall at the top of the somma.

**Megascopic Characters.**—The rock varies in megascopic characters from only slightly to strongly porphyritic, plagioclase constituting the most conspicuous phenocrysts. They are usually equant in development, very often grouped in cumuloporphyrific fabric, and vary in diameter from 0.2 to 3 *mm.* In most lavas, small sporadic phenocrysts of olivine are found, but in some, they are wholly wanting. In rare instances, it happens that small phenocrysts of hypersthene and augite occur in negligible amount. These phenocrysts are scattered through the groundmass with no trace of any regular arrangement.

The groundmass is megascopically of two types: ( $\alpha$ ) black in colour and generally porous and slaggy, and ( $\beta$ ) gray in colour and rather compact or almost free from pores and vesicles; the two, however, are connected by intermediate types. The differences between these types are attributable merely to the varying conditions under which the rocks consolidated. As a rule, the surficial part of each lava has the groundmass of  $\alpha$ -type and the inner part that of  $\beta$ -type.

**Microscopic Characters.**—Under the microscope, phenocrysts of plagioclase are always seen, but those of other minerals rarely appear in thin section.

Phenocrystic *plagioclase* is generally euhedral to subhedral,

and often forms a group of two or three individuals. The following optical properties were determined for sodium light:—

$$\begin{array}{llll} a < 1.571 & 1.572 < \beta < 1.575 & 1.578 < \gamma & \gamma - a > 0.007 \\ 2V \doteq 82^\circ \text{ supposing } \beta = 1.574 & \text{Optical character:} & \dots\dots & \text{negative.} \end{array}$$

The three principal refractive indices were determined with a number of specimens from various localities. The optic axial angle,  $2V$ , was measured with a cleavage piece of feldspar parallel to  $M(010)$  taken from the lava exposed on the sea cliff to the south of Chigasaki<sup>1)</sup> (1a; Pl. VI. AB 1). From the above optical properties, the mineral was identified as calcic bytownite with its chemical composition  $\text{Ab}_{15}\text{An}_{85}$  according to BECKE.<sup>2)</sup> Three types of twinning of this mineral were observed: those according to the Carlsbad, albite, and pericline laws. The former two are very common, while the last is only rarely met with. Albite-twinned lamellæ are generally thick and not numerous. Zonal structure due to a difference of chemical compositions is not noticeably exhibited. The mineral is generally poor in inclusions, but it sometimes contains uncrystallized or half-crystallized substance which seems to be rock mass imprisoned before consolidation.

*Olivine*, which is found in most lavas as phenocrysts though these are extremely small in number, is always subhedral to anhedral, occasionally with a resorption-border. Sometimes olivine crystals are reduced to very small grains by magmatic resorption. With the grains of this mineral separated from the chemically analysed specimen, the following optical measurement was made:—

$$a < 1.6996 < \beta < 1.7146 < \gamma \qquad \gamma - a > 0.024$$

1) 千ヶ崎 or 乳ヶ崎

2) "Zur Physiographie der Gemengteile der krystallinen Schiefer," *Denkschriften der kaiserlichen Akademie der Wissenschaften*, 75 Band, S. 103, 1913 (Wien).

From these values of the refractive indices the composition of the olivine is inferred to be about  $(\text{Fe}_2\text{SiO}_4)_{25-30}(\text{Mg}_2\text{SiO}_4)_{75-70}$  according to H. BACKLUND.

Pale light greenish *augite* and low double-refracting, weakly pleochroic *hypersthene* are extremely rare as phenocrysts. The former is in subhedral to anhedral forms, sometimes twinned on (100); the latter is always normal in optical orientation so far as observed. Sometimes the two occur in parallel intergrowth.

The *groundmass* consists of prismoid plagioclase, light greenish anhedral augite, and magnetite, usually with more or less interstitial glass. Plagioclase is here labradorite varying from  $\text{Ab}_{50}\text{An}_{50}$  to  $\text{Ab}_{35}\text{An}_{65}$  with the mean refractive index 1.558—1.565. Augite has the refractive indices  $\alpha < 1.6836$   $1.6836 < \beta < 1.6869$   $1.6975 < \gamma$ , and is comparable with the mineral described as diopside from Taberg in which the medium refractive index is 1.6836. The texture of the groundmass varies in different parts. In its megascopically black part ( $\alpha$ -type), it is docrystalline; and fine-grained irregularly shaped, often dendritic, skeletal crystals of magnetite disseminate among the plagioclase prisms and augite grains. The interstitial glass is colourless but sometimes appears brown in the vicinity of the vesicles owing to fine dusty inclusions. In its megascopically gray, compact part ( $\beta$ -type), the groundmass is nearly holocrystalline, granular intersertal, and the felsic and mafic components are present in equal amount. Here the magnetite crystals are generally large and show their own forms.

**Chemical Characters.**—A specimen from the uppermost lava (Pl. VI. DE 4) exposed on the south shore at the east end of Sashikiji<sup>1)</sup> (2c) was chemically analysed by Mr. ÔHASHI of the Geological Survey through the kindness of Prof. KORÔ, to both

1) 差本地



of whom the writer is much indebted. The analysed specimen was nearly holocrystalline, consisting of calcic bytownite, labradorite, diopsidic augite, and magnetite, with a negligible amount of olivine. This specimen has been selected for analysis because it belongs to the most widely spread type of the somma lavas, while being nearly holocrystalline, as stated, it consequently affords a correlative comparison of its mineralogical and chemical characters.

The result of the chemical analysis is as follows:—

	Weight percentage.	Molecular ratio.
SiO <sub>2</sub>	53.01	0.884
Al <sub>2</sub> O <sub>3</sub>	14.73	0.144
Fe <sub>2</sub> O <sub>3</sub>	3.38	0.021
FeO	9.42	0.131
MgO	4.97	0.124
CaO	9.09	0.162
Na <sub>2</sub> O	2.09	0.034
K <sub>2</sub> O	0.44	0.005
H <sub>2</sub> O	1.22	0.068
TiO	1.03	0.013
ZnO <sub>2</sub>	0.04	—
MnO	0.34	0.005
P <sub>2</sub> O <sub>5</sub>	0.11	0.001
Total	99.87	

OSANN'S formula.

$s=58.12$	$A=2.52$	$C=6.80$	$F=23.24$
	$a=1.55$	$c=4.18$	$f=14.27$
	$n=8.70$	$k=1.12$	

Norm.

Quartz .....	9.6
Orthoclase .....	2.8

Albite .....	17.8
Anorthite.....	29.2
Diopside .....	12.4
Hypersthene .....	19.7
Magnetite .....	4.9
Ilmenite .....	2.0
Apatite .....	0.3

Ratios.

$$\frac{\text{Sal}}{\text{Fem}} = 1.57 \quad \text{Class 'III}$$

$$\frac{\text{Q}}{\text{F}} = 0.19 \quad \text{Order 4'}$$

$$\frac{\text{Na}_2\text{O}' + \text{K}_2\text{O}'}{\text{CaO}'} = 0.37 \quad \text{Rang 4}$$

$$\frac{\text{K}_2\text{O}'}{\text{Na}_2\text{O}'} = 0.15 \quad \text{Subrang 4'}$$

According to the C. I. P. W. quantitative system, the rock belongs to 'III. 4'. 4. 4', an unnamed subrang.

**Name of Rock.**—The characteristic feature of the present rock is well seen in OSANN's formula as well as in the norm. In the values of *a*, *c*, and *f*, the present rock accords with "plagioclase-basalt of the Royat type"<sup>1)</sup>, from which, however, it is decisively distinguished in the value of *k*.

Normatively, the present rock is characterized by labradorite  $\text{Ab}_{39}\text{An}_{61}$  and contains quartz molecules in such quantities that it is classified in the quardofelic order in the quantitative system. The rock is, therefore, to be classed as "bandaite"<sup>2)</sup> according to IDDINGS's term. But as the present rock is transitional to "basalt" in its less quaric and more femic characters, it may properly be called "basaltic bandaite."

1) OSANN, *Tschermak's Min. u. Petr. Mitth.*, Bd. XX., S. 451, 1901.

2) IDDINGS, *Igneous Rocks*, Vol. II., p. 111, 1913.

2) **Hypersthene-basaltic bandaite.** (The second type of the somma lava.) (Pl. II. Fig. 1.)

This type looks like the semipatic variety of the preceding one in its megascopic appearance, but is characterized by the presence of hypersthene phenocrysts in moderate quantity.

*Mode of Occurrence.*—The rock of this type occurs only as a small flow and is exposed on the sea cliff to the south of Motomura<sup>1)</sup> (Pl. V. 1c II; Pl. VI. BC 2). As seen in Pl. VI., it is clear that lava of the present type was poured out in the middle of the outpouring of lavas of the first type, and accordingly that the petrographic difference between this type and the preceding one is not due to a difference in the time of its extrusion but must be attributed to another cause. This point will be discussed later (pp. 118–119).

*Megascopic Characters.*—Megascopically, the rock is strongly porphyritic, with numerous phenocrysts of plagioclase and moderate ones of hypersthene. They are scattered with no trace of any regular arrangement. The plagioclase is 2 mm. in average diameter and the hypersthene is of about the same size being dark green with resinous luster. The groundmass is grayish black and aphanitic, and has many small pores of rather irregular shape, averaging in diameter about 1.5 mm., uniformly distributed through the whole parts of the rock, but is not slaggy.

*Microscopic Characters.*—Under the microscope, the rock is porphyritic and semipatic. The conspicuous phenocrysts are short prismatic crystals of calcic bytownite ( $\text{Ab}_{15}\text{An}_{85}$ ). Its character is quite the same as that of the mineral in the preceding type and requires no special mention.

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Other phenocrystic minerals are pyroxenes, only in a subordinate quantity. Of these, subhedral prismatic crystals of *hypersthene* greatly predominate over those of light greenish *augite* in which  $c \wedge Z \cong 43^\circ$ . The latter are often found surrounding the former in thin shells in parallel intergrowth.

The following optical properties of hypersthene were observed:—

$$\begin{array}{lll} \alpha < 1.6906 & 1.6906 < \beta < 1.7146 & 1.7014 < \gamma \\ 2V \doteq 85^\circ \text{ supposing } \beta = 1.7 & \text{Optical character} \dots \text{negative.} \end{array}$$

Pleochroism is not strong:—

$X \dots$  light reddish brown

$Y \dots$  light reddish yellow

$Z \dots$  light bluish green.

The above optical properties of hypersthene are comparable to those of the mineral from Labrador containing 10% of FeO, which was studied by LÉVY and LACROIX. The Labrador specimen has the refractive indices:—

$$\alpha = 1.692 \quad \beta = 1.702 \quad \gamma = 1.705$$

The *groundmass* is perocrystalline and centimillimeter-grained, and consists of prismoid crystals of labradorite ( $\text{Ab}_{50}\text{An}_{50}$ ), anhedral light greenish augite, and isometric magnetite, with only a trifling amount of interstitial glass pigmented into brown with very fine dusty inclusions. The felsic and mafic components are nearly equal in quantity and the texture is granular intersertal or typically basaltic.

### 3) Two-pyroxene-basaltic bandaite. (The third type of the somma lava.) (Pl. II. Figs. 2-3.)

The rock of this type is marked by the presence in moderate

quantity of phenocrysts of both hypersthene and augite besides those of plagioclase, and by the entire absence of olivine.

**Mode of Occurrence.**—The exposure of the lavas of this type is seen only on the cliff at Gyôja<sup>1)</sup>, on the east coast, in three layers, each about 20 *m.* in thickness, intercalated by layers of ejecta (Pl. V. 3c *III*; Pl. VI. FG 6). The geologic relation between lavas of this type and those of the first type could not be observed owing to the accumulation of sands and lapilli of the central cone blown down by the wind from the caldera through the northeastern gap of the ring-wall of the somma.

**Megascopic Characters.**—The rock is megascopically fine-grained, non-vesicular and is gray, sometimes with a purplish tone due to the partial hematitization of magnetite grains in its ground-mass. It is megascopically dypatic, the phenocrysts being of plagioclase, usually less than 2 *mm.* in diameter, and of dark greenish pyroxenes, smaller and less abundant than the former but not negligible.

**Microscopic Characters.**—Microscopically, the rock is do-crystalline in crystallinity and seriate porphyritic in fabric. The most conspicuous phenocrysts are of *calcic bytownite* near  $\text{Ab}_{12}\text{An}_{88}$ , as identified from its optical properties, commonly exhibiting the Carlsbad and albite twins but rarely the pericline, and with rather scanty inclusions of augite microlites, black glass, and fine dust, arranged irregularly or zonally. Sometimes the mineral is coated by a thin layer of less calcic plagioclase (labradorite) with a distinct boundary between them. The core part has the following optical properties:—

$$\begin{array}{lll} \alpha < 1.571 & 1.574 < \beta < 1.577 & 1.578 < \gamma \\ 2V \doteq 84^\circ \text{ supposing } \beta = 1.576 & \text{Optical character} \dots \text{negative.} \end{array}$$

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The subordinate phenocrysts are of *hypersthene*, rather low in FeO as may be inferred from its optical properties, and of light greenish *augite*, subhedral to anhedral and prismoid to equant, sometimes twinned after (100). The two are found in some cases in parallel intergrowth. Their optical properties are:—

*Hypersthene*

$$\alpha < 1.6906 < \beta < 1.7146 < \gamma$$

$$2E \doteq 89^\circ \quad 2V \doteq 82^\circ \text{ supposing } \beta = 1.7 \quad \text{Optical character} \dots \text{negative.}$$

Pleochroism:—

*X* . . . light reddish brown

*Y* . . . light reddish yellow

*Z* . . . light bluish green

*Augite*

$$\alpha < 1.6869 \quad 1.6869 < \beta < 1.6906 \quad 1.7014 < \gamma \quad c \wedge Z \doteq 45^\circ$$

The angle  $c \wedge Z$  was measured on a section of augite in parallel intergrowth with hypersthene whose interference figure shows that the section is cut parallel to (010).

The intersertal *groundmass* consists of plagioclase prisms, 0.05—0.3 mm. in length, light greenish augite grains ( $\alpha < 1.6836 < \beta < 1.6869 < \gamma$ ), and magnetite, subhedral to anhedral often showing dendritic skeletal crystals.

#### 4) Hypersthene-bearing augite-olivine-bytownite-basalt.

(The fourth type of the somma lava.) (Pl. II. Fig. 4.)

Rock of this type is highly characterized by the presence of abundant olivine phenocrysts, and is decisively distinguishable from the preceding types in this respect.

**Mode of Occurrence.**—This type is a decidedly rare one, occurring only at the locality indicated on the geologic map (Pl. V.



3d) by *IV* on the east coast (Pl. VI. EF 5). The exposure at this locality is as shown in Fig. 35, where  $L_4$  is the lava of the present type, and  $L_1$  that of the first type, i. e. the most

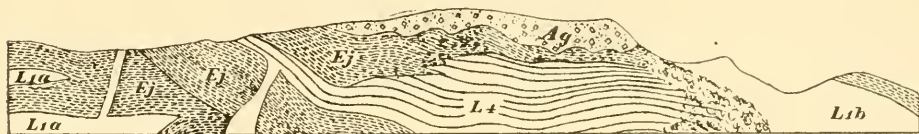


Fig. 35. *Ag*.....Agglomerate bed.  
*Ej*.....Other ejecta bed.  
*L1a L1b* .....Lava of the first type.  
*L4* .....Lava of the fourth type.

widely spread basaltic bandaite. There the present rock-type occurs in ten flows, each under 1 *m.* in thickness and with thin layers of scorïe and ashes between them. As may be seen from Fig. 35, lavas of the present type  $L_4$  must have been discharged from a local vent during the extrusion of the lavas  $L_{1a}$  and  $L_{1b}$ , both of which belong to the first type.

**Megascopic Characters.**—Megascopically, the rock is strongly porphyritic with phenocrysts of plagioclase, olivine, and augite, scattered through the groundmass without a trace of any regular arrangement. Plagioclase phenocrysts, single or grouped, are most abundant and average about 2 *mm.* in diameter, the largest being over 5 *mm.* Olivine, though small in size (<1 *mm.*), is found abundantly and is conspicuous for its characteristic luster. The augite phenocrysts, mostly in groups of two or three individuals, are about 2 or 3 *mm.* in diameter, and vary greatly in amount in different flows. The groundmass is grayish and aphanitic and has pores of various size (<3 *mm.* in diameter).

**Microscopic Characters.**—Microscopically, the rock is semipatic. Single or grouped phenocrysts of calcic bytownite ( $Ab_{15}An_{85}$ ) with the refractive indices  $\alpha < 1.571$   $1.572 < \beta < 1.575$   $1.579 < \gamma$

are seen abundantly. They are generally subhedral, commonly twinned according to the Carlsbad, albite, and rarely pericline laws, and carry rather abundant inclusions (mostly augite grains, extremely few magnetite crystals, and a fine dusty substance), usually arranged zonally in thin bands parallel to the crystal outline. The zonal structure due to chemical difference is sometimes exhibited, especially in the peripheral part, though very faintly. In the simplest case, the less calcic plagioclase surrounds the more calcic, but in some cases the more calcic and less calcic zones alternate between the most calcic core and the least calcic outermost shell.

Phenocrysts of *olivine*, next to those of plagioclase in amount, are anhedral to subhedral, generally resorbed, often with deep indentation. The alteration products, iddingsite and magnetite, are often seen deposited along the cracks. Very poor inclusions of this mineral are colourless glass and trichites.

Subordinate phenocrysts of pyroxenes, of which *hypersthene* is negligible in quantity, show the usual characters. Of the *augite* phenocrysts the following refractive indices were measured<sup>1)</sup> :—

$$\alpha' \doteq 1.6869 \quad 1.6869 < \beta < 1.6906 \quad 1.7014 < \gamma \quad \gamma' < 1.7168$$

The *groundmass* is porocrystalline, centimillimeter-grained, and granular intersertal, being built up of granular augite and prismoid plagioclase with euhedral magnetite scattered here and there and only a negligible amount of glass, very often appearing brown because of fine dusty inclusions. It is a remarkable feature of the groundmass that the mafic components nearly equal, and at times even exceed the felsic, in quantity as well as in size.

**Name of Rock.**—The present rock is so rich in olivine that it is inferred to belong to the perfelic order of the quantitative system,

1) Here  $\alpha'$  and  $\gamma'$  denote respectively the observed minimum and maximum refractive indices.

and is therefore classed as "basalt", following the definition given by IDDINGS.<sup>1)</sup>

(B) *Lavas of the Central Cone.*

5) **Miharaite.** (Pl. II. Figs. 5-6. Pl. III. Figs. 1-4.)

The central cone is built up of many lava flows intercalated by layers of ejecta, as has already been stated (p. 30). Though each of these has certain peculiar characters, both in magascopic and microscopic features, all agree so closely in their important petrographic characters that they are rightly treated as belonging to the same type.

It is a remarkable fact that no trace of olivine has ever been detected in the lavas of the central cone in contrast to the olivine-bearing somma lavas.

**Older Lava** (Pl. II. Fig. 5).—Older lavas of the central cone are exposed in layers on the inner wall of the crater. The specimen of which the following description is given came from the lowest exposed lava on the east wall of the crater.

Megascopically, phenocrysts of plagioclase, 2 or 3 mm. in diameter, are scattered moderately, and those of hypersthene, far smaller than the former, sporadically through the groundmass. The groundmass is gray to black, aphanitic, and varies from compact to more or less porous and slaggy.

Under the microscope, calcic plagioclase and hypersthene are found as phenocrysts; and less calcic plagioclase, augite, and magnetite, as the constituents of the groundmass. Interstitial glass is present in variable but generally in small quantities. The groundmass varies within a wide range both in granularity and

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1) *Igneous Rocks*, Vol. II., p. 196, 1913.

crystallinity, and the texture is accordingly from nearly hyalopilitic to granular intersertal.

**An-ei Lava (1778)** (Pl. II. Fig. 6).—The lava of 1778 is the most conspicuous now seen in Ôshima. As is shown in the geologic map (Pl. V.), extensive lava fields stretch from the top crater eastwards and southwards to the sea shores in almost uncovered condition. The field feature of this lava shows that it belongs to the “Pahoehoe” type. The vesiculation of the mass of the lava is rather evenly developed and uniformly disseminated as DALY<sup>1)</sup> says, but the size of the pores is not always very small.

Megascopically, plagioclase phenocrysts, 0.5–3 mm. across, are sparsely scattered through the compact, aphanitic groundmass with abundant vesicles varying in diameter from a few mm. to 1 cm. They are mostly spherical, but some are elongated in one direction, even to such an extent that the length is ten times the breadth.

Microscopically, plagioclase phenocrysts are always seen. The groundmass consists of plagioclase, augite, magnetite, and brown glass. Its texture varies in different parts owing to the different conditions of consolidation. A specimen from the lava field on the northern flank of the central cone shows microporphyritic groundmass (Pl. II. Fig. 6) with microphenocrysts (0.05–0.3 mm. across) of plagioclase, augite, and a few of hypersthene scattered in dopatic fabric through the black base which even in thin section is opaque owing to the fine dissemination of magnetite. Another specimen collected near the eastern end of the flow has its groundmass quite like that of  $\alpha$ -type (p. 70) of the somma lava.

**Meiji-Taishô Lava (1912–1914)** (Pl. III. Figs. 1–4).—During the eruption in 1912–'14, the extrusion of lavas took place in five

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1) *Igneous Rocks and Their Origin*, pp. 290–291, 1914.

“The Nature of Volcanic Action,” *Proceedings of the American Academy of Arts and Sciences*, Vol. XLVII, No. 3, 1911.

periods. These lavas did not run over the brim of the crater but filled the bottom of it.<sup>1)</sup>

Megascopically recognizable minerals are plagioclase and pyroxene. The former occurs abundantly as megaphenocrysts with a diameter varying mostly from 0.2 to 3 mm., while the latter is only sporadically found and is far inferior in size. The colour of the groundmass varies in different parts. In its slaggy part it is jet-black, while in its more compact part it is dark gray. The surface of each lava is often coated with a thin scoriaceous film, brown in colour.

Microscopically, the rock contains abundant phenocrysts of plagioclase, a few of hypersthene and clino-hypersthene, and a negligible amount of augite. The texture of the groundmass varies. In the megascopically gray, comparatively compact part, it is perocrystalline in crystallinity and decimillimeter-grained in granularity, consisting of prismoid plagioclase, augite grains, magnetite, and apatite (extremely rare), with only a negligible amount of interstitial glass, arranged in ophitic texture (Pl. III. Fig. 1); while in the black slaggy part, it is hyalocrystalline or docrystalline, plagioclase and augite swimming in the brown base, and is almost free from visible magnetite crystals (Pl. III. Fig. 2). In the part of the intermediate crystallinity, the groundmass is black and opaque in thin section owing to the dissemination of fine grains of magnetite (Pl. III. Figs. 3 & 4).

**Characters of the Component Minerals.**—*Plagioclase* occurs as phenocrysts and as a constituent of the groundmass. The phenocrystic one is euhedral and subhedral, and is developed in prismatic and nearly equant habits. Two or three individuals of

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1) Specimens of the earlier lavas which are now entirely buried were kindly furnished by Prof. ÔMORI and Mr. OKAMURA to whom the writer extends his grateful acknowledgements



this mineral often form a grouped phenocryst. Twinning is usually present in simple and polysynthetic lamellæ according to the albite, Carlsbad, and rarely pericline laws. Zonal structure due to chemical difference is often very faintly exhibited. The mode of zoning is not always very simple, the more calcic and less calcic



Fig. 36.

1. Most calcic.
2. More calcic.
3. Less calcic.
4. Least calcic.

feldspars being often alternately developed in successive zones (Fig. 36). It is a general rule, however, that the outermost one coating each crystal in a very

thin shell is the least calcic and the innermost one is the most calcic. The refractive indices measured with the isolated pieces are:  $\alpha < 1.572 < \beta < 1.578 < \gamma$ , so the mineral was identified as calcic bytownite with its chemical composition  $\text{Ab}_{13}\text{An}_{87}$  according to BECKE.<sup>1)</sup> The optic axial angle was determined to be approximately  $88^\circ$  supposing  $\beta = 1.575$ . The mineral contains numerous inclusions of angite, feldspar, glass, and fluid bubbles. These are often arranged in distinct zones orientating themselves parallel to the outline of the host.

The plagioclase in the groundmass is too fine to be determined accurately, but as the mineral has its refractive indices near 1.57 in average it may be slightly less calcic (sodic bytownite) than the phenocrystic one. It is prismoid in crystal habit and is very commonly twinned in two or three lamellæ.

Another mode of occurrence of plagioclase which deserves special mention is as "rhombic lamellæ" (Pl. III. Fig. 2). These are found imbedded in brown glass and are often so extremely thin that their action on polarized light is scarcely recognizable.

1) "Zur Physiographie der Gemengtheile der krystallinen Schiefer," *Denkschriften der kaiserlichen Akademie der Wissenschaften*, 75 Band, S. 193, 1913 (Wien).



They are more noticeably developed in more hyaline facies and make gradual transition to the plagioclase of common type. Most of them measure from 0.03–0.12 mm. along the longer diagonals

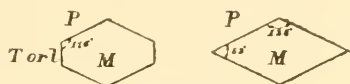


Fig. 37.

of the rhombs. Well defined rhombs have angles measuring about  $52^\circ$ ,  $116^\circ$ , and  $128^\circ$ , and thus seem to be bounded by the faces  $M(010)$ ,  $P(001)$ ,  $x(10\bar{1})$ , and  $T(1\bar{1}0)$  or  $l(110)$ , as shown in Fig. 37, i. e. the lamellæ are very thin tabular parallel to  $M(010)$ .<sup>1)</sup>

*Hypersthene* and *clino-hypersthene*.—Hypersthene occurs in subordinate amounts as phenocrysts of prismatic form measuring 0.2–1 mm. along the longest direction, being nearly euhedral to anhedral. Prismatic cleavage is sometimes noticeably exhibited and transverse cracks are often seen. Axial colours observed in thin section are:—

|| *c* . . . greenish      ⊥ *c* . . . brownish

Conoscopic examination shows that the two forms of hypersthene are present—the normal one and that of the clino-form, with the trace of the optical plane parallel and transverse to the *c*-axis respectively. In properties other than the optical orientation the two behave quite alike and have no other characteristics to distinguish

1) A similar occurrence of plagioclase is said to have been observed in the basaltic glass of Ogasawarajima (Bonin Islands), on which an account was given by the late Dr. Y. KIKUCHI ("On Pyroxenic Components in Certain Volcanic Rocks from Bonin Islands," *Jour. Sci. Coll. Imp. Univ. Japan*, Vol. III, pp. 70–73, 1889). There he observed that the "rhombic lamellæ" make gradual transition to the porphyritic crystal of plagioclase, as in the present case, and thus he confirmed that they are plagioclase (probably anorthite), as suggested by PEXEK ("Studien über lockere vulkanische Auswürflinge," *Zeitschrift d. Deutschen geol. Gesellschaft*, Bd XXX, S. 99, 1878), KREUTZ ("Ueber Vesuvlaven von 1881 und 1883," *Tschermak's Min. u. Petr. Mitth.*, Bd IV., S. 139, 1835), and DOSS ("Die basaltischen Laven und Tuffen der Provinz Haurân und vom Dîret et-Tulûl in Sirien," *Tschermak's Min. u. Petr. Mitth.*, Bd VII, S. 527, 1836). Crystal faces observed by him are as follows:—

$P(001)$ ,  $M(010)$ ,  $y(20\bar{1})$ ,  $o(11\bar{1})$ ,  $p(111)$ ,  $x(101)$ .

Twinning according to the albite and Carlsbad laws was also observed by him in the rock of Ogasawarajima.

them from each other. Polysynthetic twinning after (100) which is said to be very characteristic of clino-enstatite<sup>1)</sup> is entirely absent in our clino-hypersthene.

*Augite* is a light greenish variety. It is found very rarely as microphenocrysts, but abundantly in the groundmass as one of the essential ingredients, and ranges from nearly euhedral to anhedral. Sometimes the mineral occurs in a thin rim around hypersthene in parallel intergrowth. The common type of twinning after (100) is often met with, while the intergrowth with plagioclase penetrating each other in cross is sometimes seen.

*Magnetite* occurs in rather large euhedral crystals in the more crystalline part, reaching as large as 0.06 mm. in diameter, while in the less crystalline part it shows very often dendritic skeletal forms.

*Apatite* is almost absent, its needle with characteristic negative elongation (0.02 mm. in length) was detected only in one instance in thin section from the perocrystalline part of the recent lava.

*Glass* base is uniformly brown in thin section. Its index of refraction was measured with the powders from the more hyaline part of the recent lava to be  $n=1.593-1.596$ . This high refractive index shows the basic nature of the glass.

**Chemical Characters.**—The chemical analyses of three of the lavas and one of the scoriae of the recent eruption gave the following results :<sup>2)</sup>—

	A	B	C	D	E
SiO <sub>2</sub>	51.94	51.13	51.32	51.40	51.45
Al <sub>2</sub> O <sub>3</sub>	15.36	17.75	16.84	17.42	16.84
Fe <sub>2</sub> O <sub>3</sub>	3.11	0.45	0.65	1.74	1.49

1) O. ANDERSEN, "System Anorthite-Forsterite-Silica," *Am. Jour. Sci.* (4), Vol. XXXIX., p. 419, 1915.

2) These analyses were made in the Geological Survey and were published by OKAMURA in his report on the recent eruption (*Report Geol. Surv. Japan*, No. 48, 1914).

	A	B	C	D	E
FeO	9.81	11.58	12.14	10.26	10.95
MgO	4.93	4.40	4.22	4.36	4.48
CaO	10.54	10.83	10.85	10.51	10.71
Na <sub>2</sub> O	0.77	1.30	1.52	1.44	1.23
K <sub>2</sub> O	0.49	0.36	0.41	0.22	0.37
H <sub>2</sub> O	0.43	0.95	1.00	0.49	0.72
TiO <sub>2</sub>	1.53	1.01	1.01	1.44	1.27
P <sub>2</sub> O <sub>5</sub>	0.89	trace	trace	0.15	0.26
MnO	0.21	0.25	0.29	0.03	0.19
Total	100.01	100.01	100.25	99.46	99.96

A. . . . . Lava in April, 1912.

B. . . . . Lava in October, 1912.

C. . . . . Scoria in October, 1912.

D. . . . . Lava in December, 1912.

E. . . . . The average of the above four analyses.

OSANN'S formulæ.

	A	B	C	D	E
<i>s</i>	57.69	56.24	56.26	57.10	56.84
<i>A</i>	1.10	1.63	1.88	1.63	1.56
<i>C</i>	8.66	8.68	8.81	9.52	9.15
<i>F</i>	22.86	22.14	22.36	20.60	21.74
<i>a</i>	0.67	0.97	1.14	1.03	0.96
<i>c</i>	5.31	5.79	5.33	6.09	5.64
<i>f</i>	14.02	13.24	13.53	12.97	13.40
<i>n</i>	7.06	8.40	8.62	9.20	8.33
<i>k</i>	1.23	1.02	1.10	1.16	1.15

Norms.

	A	B	C	D	E
Quartz	14.2	6.1	5.3	9.2	8.8
Orthoclase	2.8	2.2	2.2	1.1	2.2
Albite	6.3	11.0	13.1	12.1	10.5

	A	B	C	D	E
Anorthite	37.3	41.4	37.8	40.6	39.2
Diopside	8.4	10.3	13.6	9.1	10.3
Hypersthene	21.4	25.5	24.3	21.4	23.2
Magnetite	4.4	0.7	0.9	2.6	2.1
Ilmenite	2.9	2.0	2.0	1.7	2.4
Apatite	1.9	—	—	0.3	0.6

Ratios.

	A	B	C	D	E
Sal	1.55	1.58	1.43	1.79	1.57
Fem					
$\frac{Q}{F}$	0.31	0.11	0.10	0.17	0.17
$\frac{Na_2O' + K_2O'}{CaO'}$	0.13	0.17	0.21	0.17	0.17
$\frac{K_2O'}{Na_2O'}$	0.42	0.19	0.16	0.09	0.20

Of the four analysed rocks, two (B and C) belong to *aureognose* ('III. '5. 4. 4'), one (D) to *bandose* (II'. 4'. 4'. 5.), and one (A) to an unnamed subrang ('III. 4. '5. 4.). The average of the four analyses places the rock at 'III. 4'. 4'. 4.

**Name of Rock.**—As is clear from the above description, the rock is basaltic, but is remarkable in its amount of silica relative to other components. This amount is not only sufficient to form the highest silicates but yields it to excess, which appears in the norms as occult quartz, so that the rock finds its position in average at the quarzofelic order in the C. I. P. W. quantitative system. The normative plagioclase, on the other hand, is as calcic as bytownite ( $Ab_{15}An_{85}$  in A,  $Ab_{22}An_{78}$  in B,  $Ab_{27}An_{73}$  in C,  $Ab_{21}An_{79}$  in D, and  $Ab_{22}An_{78}$  in average). The rock is, therefore, an *aphanite belonging to the quarzofelic order or very near to it, with the normative bytownite*.

The rocks with strongly calcic normative plagioclase usually

belong to the perfelic order with either a negligible amount of quartz or none, while those belonging to the quardofelic order are not yet known to have such calcic plagioclase as bytownite.<sup>1)</sup> Thus, the rock now under consideration is quite unique in its composition.

Of the quardofelic aphanites characterized by lime-soda-feldspars, those with normative oligoclase, andesine, and labradorite are respectively called ungaite, shastaite, and bandaite. It is clear from the characters described above that the present rock must occupy the vacant position next to bandaite, or thereabout in the same group, being characterized by normative bytownite. Thus, it seems to be necessary, on account of its peculiar characters, to give a new name to our rock, for which "*miharaite*"<sup>2)</sup> is here proposed, derived from the name of the central cone, Miharayama.<sup>3)</sup>

In the following table, miharaite is compared with (i) the type-basalt given by ROBINSON,<sup>4)</sup> (ii) the alboranite from Isla de la Nube, Alboran, described by BECKE<sup>5)</sup>, and (iii) the diabase from Barima District, British Guiana, described by HARRISON.<sup>6)</sup>

A. . . . .	Average composition of the present rock 'III. 4'. 4'. 4.
B. . . . .	Type-basalt, calculated by ROBINSON from 246 analyses in II. 5. 4. 3., III. 4. 3. 4., III. 5. 3. 4 & 5., III. 5. 4. 3., III. 5. 5.
C. . . . .	Alboranite, 'III. 5. '4. 3(4). <i>auvergnose</i> .
D. . . . .	Diabase, 'III. '5. '5. 5. <i>ouenose</i> .

1) IDDINGS says, in a description of the phanerites belonging to the same group as the present rock, that the feldspars of any rock of this group almost never average as calcic as bytownite-anorthite (*Igneous Rocks*, Vol. II, p. 44, 1913).

2) "Mihara-gan" (三原岩) in Japanese.

3) 三原山

4) "The San Franciscan Volcanic Field, Arizona," *U. S. Geol. Surv., Prof. Paper* No. 76, p. 101, 1913.

5) *Tschermak's Min. u. Petr. Mitth.*, Bd. XVIII, S. 525, 1899.

6) *Rep. G. N. W. District*, II, p. 6, 1898. Reproduced in the following works:—

H. S. WASHINGTON, "Chemical Analyses of Igneous Rocks," *U. S. Geol. Surv., Prof. Paper* No. 14, p. 337, 1903.

IDDINGS, *Igneous Rocks*, Vol. II, p. 227, 1913.

	A	B	C	D
SiO <sub>2</sub>	51.45	48.0	53.13	50.76
Al <sub>2</sub> O <sub>3</sub>	16.84	16.3	15.61	16.83
Fe <sub>2</sub> O <sub>3</sub>	1.49	4.0	2.33	4.16
FeO	10.95	7.6	8.23	4.45
MgO	4.48	7.3	5.80	10.09
CaO	10.71	9.9	11.75	11.30
Na <sub>2</sub> O	1.23	2.8	1.86	0.97
K <sub>2</sub> O	0.37	1.1	1.76	0.06
H <sub>2</sub> O	0.72	1.4	0.73	0.14
TiO <sub>2</sub>	1.27	1.4	—	0.46
P <sub>2</sub> O <sub>5</sub>	0.26	0.3	—	—
MnO	0.19	0.2	—	0.69
Total	99.96	100.3	101.21	99.91

Norms.

	A	B	C	D
Quartz	8.8	—	2.0	6.7
Orthoclase	2.2	6.7	10.6	0.6
Albite	10.5	23.6	15.7	8.4
Anorthite	39.2	28.6	28.9	41.1
Diopside	10.3	15.6	24.8	11.8
Hypersthene	23.2	5.9	15.7	23.8
Olivine	—	9.7	—	—
Magnetite	2.1	5.8	3.3	6.1
Ilmenite	2.4	2.7	—	0.9
Apatite	0.6	1.9	—	—

(C) *Rocks constituting the Demolished Igneous Bodies along the Western Half of the Northern Coast.*

The rocks constituting the ruined igneous bodies along the western half of the northern coast (pp. 38-44) contain a fair



amount of phenocrysts of olivine and other mafic minerals in contrast to the somma lavas of the first type (p. 67), in which these minerals are either entirely wanting or negligible as phenocrysts. A moderate quantity of olivine in the rocks of the ruined igneous bodies indicates that these may belong to the perfelic order of the quantitative system. From this character as well as from others described below, the rocks are to be classed as "basalt" following the definition of this term given by IDDINGS.<sup>1)</sup>

#### 6) Two-pyroxene-olivine-anorthite-basalt. (Pl. III. Fig. 5.)

**Mode of Occurrence.**—The rock occurs in several lava flows constituting the ruined igneous body of Chigasaki<sup>2)</sup> (1a; pp. 38–41; Pl. VI. GA 14).

**Megascopic Characters.**—The rock shows very conspicuous phenocrysts of plagioclase, equant, mostly 2 or 3 mm. but sometimes as large as 1 or 2 cm. in diameter. Phenocrysts of olivine, hypersthene, and augite are also seen but are far inferior both in size and quantity, to those of plagioclase, being commonly less than 1 mm. in diameter.

The groundmass is megascopically aphanitic, gray and rather compact.

**Microscopic Characters.**—The phenocrystic minerals seen under the microscope are anorthite, olivine, hypersthene, and augite, in quantitative order.

The large phenocrystic *anorthite* has the following optical properties:—

- (1) Extinction angle on  $M$  (010):  $-34^{\circ}8' \pm 32'$
- (2) Refractive indices:  $\alpha < 1.578 < \beta < 1.582 < \gamma$
- (3) Positions of the optic axes relative to  $M$  (010):

1) *Igneous Rocks*, Vol. II, p. 111, 1913.

2) 千ヶ崎 or 乳ヶ崎

$$\begin{cases} \varphi = 53^\circ & \varphi' = 87^\circ 30'^{1)} \\ \rho = 2^\circ 38' & \rho' = 80^\circ 22' \end{cases}$$

(4) Inclination of optical plane to the side pinacoid :

$$\text{O.P.} \wedge M(010) = 75^\circ 35'$$

(5) Optic axial angle :  $2V = 81^\circ 40'$

(6) Optical character . . . . . negative.

From the values of refractive indices, the mineral was identified as anorthite with its chemical composition  $\text{Ab}_{95}\text{An}_{05}$  according to BECKE.<sup>2)</sup> Optical constants other than refractive indices also show a close agreement with those of anorthite.

The mineral encloses small crystals of olivine,  $(\text{Fe}_2\text{SiO}_4)_{13-19}$   $(\text{Mg}_2\text{SiO}_4)_{87-81}$ , with the refractive indices  $\alpha < 1.678 < \beta < 1.691 < \gamma$ .

Plagioclase, as microphenocrysts, is also anorthite with refractive indices similar to the above, euhedral to subhedral, commonly twinned according to the Carlsbad and albite laws, but rarely to the pericline and Manebach laws. Some of the plagioclase crystals are almost free from inclusions, but most of them include rather abundantly anhedral grains of light greenish augite and uncrystallized or partly crystallized opaque masses (slag), which latter may have been imprisoned prior to crystallization. Olivine is only rarely found



1. Most calcic.
2. Medium calcic.
3. Least calcic.

Fig. 38.

as an inclusion. Zonal arrangement of inclusions is very well developed in some cases. Zonal structure due to chemical difference is almost lacking except that the less calcic plagioclase forms the shell of the

anorthite phenocryst. In very rare cases a more complex zoning (Fig. 38) is extremely faintly exhibited.

1) As to the meanings of  $\varphi$ ,  $\rho$ ,  $\varphi'$ , and  $\rho'$  see Fig. 34, p. 65. The values in (3)—(6) were calculated by supposing  $\beta = 1.578$ .

2) "Zur Physiographie der Gemengteile der krystallinen Schiefer," *Denkschriften der kaiserlichen Akademie der Wissenschaften*, 75 Bd. S. 103, 1913 (Wien).

*Olivine* phenocrysts, next to those of anorthite in amount but far less numerous, range in diameter from 0.3 to 1 *mm.* These have irregular outlines with rounded corners and sometimes deep indentations, each being fringed with a resorption-border, consisting of magnetite grains, surrounded in turn by a specially fine-grained thin layer similar in composition to the groundmass. The refractive indices of olivine crystals were measured with the result:  $\alpha < 1.678 < \beta < 1.691 < \gamma$ . The mineral is therefore inferred to have the chemical composition  $(\text{Fe}_2\text{SiO}_4)_{13-19}(\text{Mg}_2\text{SiO}_4)_{87-91}$ . The mineral is fresh, but irregularly cracked, and is almost free from inclusions except fluid enclosures which are very rarely found.

Subordinate phenocrysts of hypersthene and augite are present. *Hypersthene* phenocrysts are subhedral and prismatic, the largest in thin section measuring 1 *mm.* along the *c*-axis, and are traversed by the usual cleavage lines and other cracks, of which those perpendicular to the *c*-axis are conspicuous. The mineral has the optical plane parallel to (010) and shows its characteristic pleochroism. As inclusions it often contains small plagioclase crystals.

Light greenish *augite* phenocrysts, 0.8 *mm.* across in the largest example are euhedral to anhedral, twinned sometimes on (100).

A parallel growth of two pyroxenes is commonly seen, the hypersthene being always enclosed by a very thin rim of augite.

The minerals in the *groundmass* are prismoid plagioclase which is at least as calcic as labradorite-bytownite with the maximum symmetrical extinction angle reaching  $45^\circ$ , light greenish anhedral augite, and euhedral isometric magnetite, with an extremely small amount of interstitial glass, light brown in colour, clouded by numerous globules. These component minerals vary from 0.01 to 0.1 *mm.* in diameter and build up the granular intersertal ground-

mass which is high in crystallinity (nearly holocrystalline) but low in granularity.

**7) Olivine-bytownite-basalt (*a*). (Pl. III. Fig. 6.)**

**Mode of Occurrence.**—The rock occurs as lavas constituting the ruined igneous body underlying Kazahaya<sup>1)</sup> (1a; p. 41; Pl. VI. GA 13).

**Megascopic Characters.**—The rock is dark gray and is strongly porphyritic. The phenocrysts are mainly of plagioclase with diameters from 1 to 3 mm. Minute olivine phenocrysts are seen in smaller quantities. Irregular pores with diameters, mostly from 1 to 2 mm. and in maximum 5 mm., are distributed through the rock mass.

**Microscopic Characters.**—Microscopically, the rock is doleritic. Phenocrysts of *plagioclase*, which is calcic bytownite ( $\text{Ab}_{13}\text{An}_{87}$ ) with the refractive indices  $\alpha < 1.572 < \beta < 1.578 < \gamma$ , are generally subhedral, twinned as usual, and often carrying inclusions of augite, uncrystallized groundmass, and fine dusty substances. Zonal structure due to chemical difference is only very faintly developed or almost lacking.

The microphenocrysts of slightly greenish *olivine*,  $(\text{Fe}_2\text{SiO}_4)_{17-19}$   $(\text{Mg}_2\text{SiO}_4)_{7-9}$  ( $\alpha < 1.678 < \beta < 1.691 < \gamma$ ), averaging about 0.2–0.3 mm. in length, are anhedral often with deep indentations, remarkably traversed by cleavage lines and cracks perpendicular to the *c*-axis, and not infrequently surrounded by the alteration product, brownish yellow iron oxide.

These phenocrysts are scattered through the nearly holocrystalline, centimillimeter-grained, granular intersertal *groundmass*. The minerals that build up the groundmass are prismoid plagioclase

(1) 風早

(labradorite-bytownite) which is simply or polysynthetically twinned, light greenish anhedral augite occasionally twinned on (100), and small isometric magnetite. Colourless glass enclosing a fine dusty substance is found very sparingly as the interstitial matrix.

### 8) Olivine-bytownite-dolerite. (Pl. IV. Fig. 1.)

**Mode of Occurrence.**—To the east of Kazahaya (1a), igneous bodies are exposed on the sea cliff in the form of lavas and intrusives (p. 41; Pl. VI. GA 10–11). The rock specimen here described was taken from the westernmost intrusive mass which appears to be a congealed vent (Pl. VI. GA 11).

**Megascopic Characters.**—The rock is megascopically fine-grained non-vesicular, and is gray in colour. Porphyritic components recognizable with the naked eye are plagioclase, 5 mm. in maximum diameter with nearly equant development, and olivine, less abundant and smaller than the former.

**Microscopic Characters.**—Under the microscope, the phenocrysts of *calcic bytownite*,  $\text{Ab}_{15}\text{An}_{85}$  with the refractive indices  $\alpha < 1.571$   $1.572 < \beta < 1.575$   $1.577 < \gamma$ , show the usual characters. They are generally subhedral, twinned, very faintly exhibit zonal structure, and commonly carry inclusions.

Subhedral to anhedral *diopsidic augite*, occasionally twinned on (100), and anhedral *olivine*,  $(\text{Fe}_2\text{SiO}_4)_{13-15}(\text{Mg}_2\text{SiO}_4)_{87-81}$  ( $\alpha < 1.678$   $> \beta < 1.691 < \gamma$ ), with brown iron oxide deposited along the cracks that traverse the mineral, are seen as microphenocrysts, less than 1 mm. in diameter.

The nearly holocrystalline *groundmass* consists of sodic bytownite, light coloured diopsidic augite, and magnetite, with only a trifling amount of brown glass clouded with fine dust.

The characteristic feature of the groundmass is high granularity, being decimillimeter-grained and doleritic in texture.

### 9) Olivine-bytownite-basalt ( $\beta$ ). (Pl. IV. Fig. 2.)

**Mode of Occurrence.**—This rock constitutes the igneous body to the west of Okata<sup>1)</sup> (2a; pp. 41–42; Pl. VI. GA 9).

**Megascopic Characters.**—Megascopically, the rock is semipatic with abundant phenocrysts of plagioclase, 1–4 mm. in diameter, scattered among the grayish, aphanitic, more or less porous groundmass. Olivine crystals are found far smaller in size and less in quantity.

**Microscopic Characters.**—Microscopically, the single or grouped phenocrysts of *calcic bytownite*,  $\text{Ab}_{12}\text{An}_{88}$  ( $a < 1.574 < \beta < 1.578 < \gamma$ ), are equant, mostly subhedral, and commonly twinned, often exhibiting a very faintly marked zonal structure. Inclusions, sometimes with zonal arrangement, are as usual.

*Olivine* phenocrysts, 0.05–0.7 mm. across in average, with rounded corners and indentations, are comparatively common. The refractive indices are  $1.678 < \beta < 1.691$ , so the composition of the mineral is inferred to be  $(\text{Fe}_2\text{SiO}_4)_{13-19}(\text{Mg}_2\text{SiO}_4)_{87-81}$ . Secondary iron oxide is seen along the margin of the crystal, and iddingsite along the cracks.

The *groundmass* is almost holocrystalline, centimillimeter-grained, and basaltic, being built up of prismoid plagioclase (extinction angle  $> 30^\circ$ ), anhedral light greenish augite, and small isometric magnetite.

### (D) Rocks occurring as Dykes.

Dykes are seen at several places in the island. On the cliff opposite to Fudeshima<sup>2)</sup> (3d), numerous dykes are exposed, as has

1) 岡田    2) 筆島



already been stated (pp. 24–25; Pl. VI. EF). Dykes are also seen, one at the foot of the western wall of the crater-harbour Habu<sup>1)</sup> (3e; p. 22; Pl. VI. DE), and four on the ring-wall of the somma indicated by × on the geologic map (Pl. V. 1c and 2d). These are olivineless basaltic bandaite with characters similar to those of the first type of the somma lava. They are of two types:—

**10) Olivineless basaltic bandaite ( $\alpha$ ).** (Pl. IV. Fig. 3.)

The rock of dykes piercing the cliff opposite to Fudeshima is megascopically compact, non-vesicular and is semipatic with megaphenocrysts of plagioclase, from 5 mm. downwards in diameter.

Microscopically, the phenocrysts of *calcic bytownite*  $\text{Ab}_{16}\text{An}_{84}$  are mostly in euhedral to subhedral stout prismatic to equant forms, and usually exhibit very faintly marked zonal structure. The *groundmass* consists of light greenish augite, plagioclase, less calcic than the phenocrystic one, and magnetite, arranged in texture near the ophitic fabric. The characteristic feature of the groundmass is high crystallinity and high granularity, it being almost holocrystalline and centimillimeter-grained.

**11) Olivineless basaltic bandaite ( $\beta$ ).** (Pl. IV. Fig. 4.)

The rocks of the other dykes, of which the southernmost one on the western ring-wall of the somma is taken as representative, are gray, compact without any vesicles. The plagioclase phenocrysts are very small, rarely over 1 mm. across, and are not conspicuous though they are fairly abundant. A few hypersthene phenocrysts are also seen.

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1) 波浮

Microscopically, subhedral phenocrysts of *calcic bytownite* ( $\text{Ab}_{16}\text{An}_{84}$ ) with usual characters and a few anhedral ones of *hypersthene* are found. The *groundmass* consists of small plagioclase prisms, augite anhedrons, and magnetite grains, with a small amount of colourless glass as interstitial matter. Only one crystal of apatite was found in a thin section. These component minerals of the groundmass vary from 0.003 to 0.04 mm. in diameter and arrange themselves in granular intersertal texture.

### (E) *Ejecta*.

#### 12) Ashes, Sands, Lapilli, and Bombs.

Ejecta are not less important than lavas in the building up of the volcano Ôshima. They are found in many layers alternated with lavas.

In size they are of four grades—(1) ashes, (2) sands, (3) lapilli, and (4) bombs.

**Ashes and Sands.**—These are brown, black, or yellowish in colour; sometimes as red as rouge, having been scorched by the intense heat of the molten lava. Ashes and sands treated with HCl were observed under the microscope to consist mainly of splinters of glass and fragments of calcic bytownite with only a negligible amount of fine pieces of the minerals that constitute the groundmass of the lava. This fact indicates that these ashes and sands originated in the magma itself before the consolidation of the groundmass and did not come from the disturbed and shattered portions of the rocky walls through which the vent was drilled. These form what Pirsson<sup>1)</sup> terms “vitric

1) “The Microscopic Characters of Volcanic Tuffs,” *Am. Jour. Sci.* (4), Vol. XI., p. 191, 1915.

tuff" and "crystal tuff." Ashes occasionally form *centre granulé* or *pisolite*, as was found interstratified on the ring-wall of the somma, some 500 m. southwest of Kagamihata<sup>1)</sup> (1c).

**Lapilli.**—There are two kinds of ejecta of the lapilli grade, viz. fragments of the pre-existing rocks and juvenile ones. The latter which far predominate over the former are glassy and scoriaceous, and often contain phenocrysts of calcic bytownite. In most cases, lapilli form very thin beds, rarely exceeding 20 cm. in thickness, between the ash and sand layers, though they sometimes form thick accumulations, as for example on the cliff opposite to Fudeshima<sup>2)</sup> (3d; pp. 25–26). The surfaces of the ground in the caldera and the apical part of the somma are loosely covered by the lapilli of the central cone.

**Bombs.**—The larger blocks of the pre-existing rocks are imbedded in ash and sand beds and form agglomerate beds, which are however very rare. Bombs that originated in molten lavas are scattered around the crater on the upper slopes of the central cone. They are multifarious in shape—spindle-shaped, subspherical, spheroidal, etc. Their size is also of wide range. A very large specimen found near Kawajiri,<sup>3)</sup> the lowest point of the crater margin (*K* in Fig. 20, p. 33), has a diameter of over 1 m. Petrographically, the bombs do not differ from the lavas of the central cone, namely miharaite. Parallel arrangement of phenocrystic minerals which is said often to have been observed in the bombs of other volcanoes is not markedly seen in these. This may be due to the high fluidity of the molten lava. It is an interesting fact that bombs sometimes contain blocks of earlier lavas as nuclei around which new lava-materials are coated.

**Pele's Hairs.**—Among the ejecta of a peculiar form is black

1) 鏡端

2) 筆島

3) 川尻

Pele's hair or glass cotton, found and collected by NAKAMURA in 1907 between narrow crevices of lava in the central Mihara<sup>1)</sup> crater. This is the only specimen ever found in our country. History records the fall of Pele's hairs during the eruption on August 31, 1777 (p. 56).

### 13) Micro-allivalite. (Pl. IV. Fig. 5.)

At the foot of Kazahaya<sup>2)</sup> (1a), imbedded in an ash layer (Pl. VI. GA 12) between the lavas of olivine-bytownite-basalt (p. 92) which constitute a small igneous body, the writer found a coarse-grained holocrystalline block, about 3 cm. across, which is petrographically identical to that ejected in the eruption of Sakurajima<sup>3)</sup> in 1914, at the southern extremity of Kyûshû, described by KOTÔ<sup>4)</sup> under the new name of "*micro-allivalite*." Specimens of similar motex were also collected by TSUJIMURA on Miyakejima<sup>5)</sup>, one of the Idzu Islands.

The block may be what LACROIX calls "*enclaves homogènes*" or HARKER calls "*cognate xenolith*." The writer's view on the genesis of this phanero-crystalline mass will be given later (pp. 121-122).

Our micro-allivalite consists of anorthite and greenish olivine, each grain ranging in diameter from 1 to 5 mm.

*Anorthite* has the refractive indices:  $\alpha < 1.575$   $1.581 < \beta < 1.584$   $1.583 < \gamma$ , so that the chemical composition of the mineral is inferred to be  $\text{Ab}_5\text{An}_{95}$ . It is twinned according to Carlsbad, albite, pericline, and Manebach laws.

1) 三原            2) 風早            3) 櫻島

4) "The Great Eruption of Sakurajima in 1914," *Jour. Sci. Coll. Imp. Univ. Tôkyô*, Vol. XXXVIII, Art. 3, p. 195, 1916.

5) 三宅島

*Olivine* is traversed by numerous cracks. It is  $(\text{Fe.SiO}_4)_{12-13}$   $(\text{Mg}_2\text{SiO}_4)_{88-82}$  with the refractive indices:—

$$\alpha < 1.636 < \beta < 1.687 < \gamma$$

Observed maximum refractive index  $< 1.7185$

Small interstices between the large individuals of the minerals are filled with a material containing hypersthene, similar to the groundmass of the lava.

#### 14) Augite-micro-diorite. (Pl. VI. Fig. 6.)

An ejected block of rather acidic nature was found at the northern foot of Kagamihata<sup>1)</sup> (1c) imbedded in the uppermost bed of agglomerate.

It is a holocrystalline, fine-grained (mostly 0.3–1.5 mm. in diameter) mass of hypidiomorphic granular texture, consisting essentially of plagioclase and augite with magnetite and apatite as accessories.

*Plagioclase* belongs to andesine-labradorite with chemical compositions ranging from  $\text{Ab}_{65}\text{An}_{35}$  to  $\text{Ab}_{43}\text{An}_{57}$ , determined by the refractive indices (1.55–1.56). These plagioclases are twinned simply (Carlsbad law) and polysynthetically (albite law) and exhibit noticeable zonal structures. In the simplest case the innermost

zone is the most calcic, successive ones become more and more sodic with gradual transition; while not a few show the more complex manner of zoning as shown in Fig. 39.

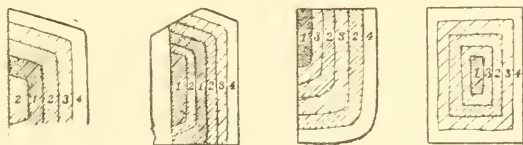


Fig. 39.

- |                 |                 |
|-----------------|-----------------|
| 1. Most calcic. | 2. Less calcic. |
| 3. More sodic.  | 4. Most sodic.  |

*Augite* is a greenish, high double-refracting one, traversed by characteristic cleavage lines parallel to (110) and often twinned on (100). It is noteworthy for its pleochroism. Pleochroism is noticeable in thicker sections, especially in those which extinguish nearly straight. It is as follows:—

$X'$ .....yellowish green  
 $Z'$ .....deep green  
 Absorption  $Z' > X'$

Here,  $X'$  and  $Z'$  respectively denote the vibration directions of the faster and the slower rays in section.

The observed refractive indices for sodium light of this unusual augite are given below. For comparison, those of the minerals from other localities which have like optical properties are cited in parallel columns.

	$\alpha$	$\beta$	$\gamma$
Pleochroic augite, Ôshima <sup>1)</sup>	$\alpha \leq 1.698$ $1.691 < \alpha'$	$1.701 < \beta < 1.716$	$1.701 < \gamma$ $\gamma' < 1.715$
Augite, Pojuna	1.688	1.701	1.713
Augite, Renfrew	1.6975	1.7039	1.7227
Augite, Boreslan	—	1.70	—
Dark green diopside, Nordmarken	—	1.7047	—

Optical plane  $\parallel$  (010).

Augite sometimes includes small crystals of plagioclase.

*Magnetite* is found as an accessory ingredient in subhedral crystals and *apatite* is as usual in small needles with characteristic negative elongation.

The interstices of the component minerals are often filled with a colourless salic matter with somewhat lower refractive indices

1) Here  $\alpha'$  and  $\gamma'$  respectively denote the observed minimum and maximum refractive indices.



but similar double refraction to the afore-mentioned plagioclase, and show a micrographic fabric.

Of the many kinds of phanero-crystalline blocks found in the volcanoes of Japan, one somewhat similar to that described here was discovered by HIRABAYASHI<sup>1)</sup> among the ejecta of Fuji<sup>2)</sup>, being especially abundant around the crater of one of its parasitic cones, Hôeizan.<sup>3)</sup> It consists of anorthite, augite, hypersthene, and magnetite. He considered it as a fragmented block of a deep-seated dyke since a rock with similar petrographic characters was actually observed occurring as a dyke in the highly dissected Ashitaka<sup>4)</sup>, an older volcano adjacent to Fuji.

The genesis of our micro-diorite will be discussed on pp. 121-125.

## V. History of the Magma.

In the foregoing pages, the various rock-types of Ôshima have been described in detail. Each of these rock-types has certain distinguishing characteristics, but all of them differ only slightly from one another, agreeing so closely in their essential features that they are considered to have originated from the same magma. What, then, is this original magma? How have the various rock-types and the petrographic characters as now seen been developed from it? The present chapter is an attempt to answer these questions and to discuss the history of the magma of Ôshima.

The more important rock-types, except those occurring as dykes and ejecta, are :—

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1) "Volcanoes Fuji and Ashitaka," *Report Earthq. Invest. Com.*, No. 24, 1899 (in Japanese).

2) 富士

3) 寶永山

4) 愛鷹

	Names of rocks	Phenocrysts			Ground-mass
		Olivine	Plagioclase	Pyroxenes	
Rocks constituting the demolished igneous bodies along the northwestern coast	Two-pyroxene-olivine-anorthite-basalt	$(\text{Fe}_2\text{SiO}_4)_{13-19}$ $(\text{Mg}_2\text{SiO}_4)_{87-81}$ Comparatively abundant	Anorthite $\text{Ab}_{55}\text{An}_{45}$	Hypersthene and augite	Consisting of plagioclase (from sodic labradorite to sodic bytownite), augite, magnetite, and glass.
	Olivine-bytownite-basalt ( $\alpha$ and $\beta$ )			Comparatively abundant	
	Olivine-bytownite-dolerite			Absent	
Somma lavas	Basaltic bandaite (the commonest ) somma lavas	$(\text{Fe}_2\text{SiO}_4)_{25-30}$ $(\text{Mg}_2\text{SiO}_4)_{75-70}$ Slight or absent	Calcic bytownite near $\text{Ab}_{15}\text{An}_{85}$	Augite Slight	
	Hypersthene-basaltic bandaite	Absent		Hypersthene and augite	
	Two-pyroxene-basaltic bandaite	Absent		Slight or absent	
	Hypersthene-bearing augite-olivine-bytownite-basalt	Comparatively abundant		Hypersthene: moderate	
				Augite: slight	
Central cone lavas	Miharaite	Absent		Hypersthene and augite	
				Slight	

The above table shows that the main difference between the various rock-types exists in the amount and character of the phenocrysts of olivine and pyroxenes, both of which are of comparatively high specific gravity. This fact suggests the importance of gravitational effects on these heavy crystals.

As to the effect of the separation and subsidence of crystals

in the magma, BOWEN<sup>1)</sup> made a thorough consideration, based on the results of recent experiments with artificial silicate mixtures which are comparable to the natural magma.

It was seen in the rocks of Ôshima that the observed facts correspond, at least in a general sense, to what might be expected from BOWEN's theory.

Before a detailed petrologic discussion is given, the writer will here briefly outline the conclusion to which he has been led.

The original magma from which the rocks of Ôshima were derived was basaltic; from it the crystals of olivine, hypersthene (partly clino-hypersthene), augite, and plagioclase separated in the course of cooling before being extruded as lavas. Of these minerals, the former three, being much heavier than the magma, sank in the magma basin as they crystallized out; while the last mentioned, matching the magma closely in density, remained practically suspended in it. Thus, the heavy crystals relatively concentrated toward the bottom. The observed rock-types represent various parts of the magma basin differentiated as above, or different stages of the subsidence of the heavy crystals, but represent only one stage of the cooling of the magma.

### Probable High Fluidity of the Magma of Ôshima.

The facility of the movement of crystals in the magma must be greatly influenced by the viscosity of the latter.

The data at hand suggest a probable high fluidity of the magma of Ôshima.

In the first place, it is known of various melts that their

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1) "The Later Stages of the Evolution of the Igneous Rocks," *Jour. Geol.* Vol. XXIII., Supplement to No. 8, 1915.

fluidity increases inversely their content of silica, and DOELTER instanced the magma of plagioclase-basalt as one of the most fluidal magmas. The strongly basic nature of our rocks ( $\text{SiO}_2$  51.13–53.01%) suggests that the magma from which they were derived was highly fluidal.

The behaviour of the magma in the intratelluric stage cannot be discerned, but its behaviour after being extruded as lavas can be inferred from observed facts. As already stated (p. 13), each of the lava flows is very thin, being mostly from a few to several meters, but the crystallinity of the groundmass is very high, perocrystalline, in spite of the possible greater tendency to consolidate as glassy rocks owing to the rapid cooling in such thin lavas. This must be due to the high fluidity of the lavas.

The presence of volatile fluxes and a rise of temperature would naturally diminish the viscosity of the melts. Moreover, according to Vogt's researches on slags, the rate of diminution of viscosity with rise of temperature is greater for those of basic than for those of acidic composition. Thus the fluidity of the basic magma of Ôshima, which is very fluidal even in the effusive stage, must be still greater in the intratelluric stage when the temperature is far higher and an amount of volatile fluxes is present as is indicated by the vesicular nature of the lavas.

High fluidity of the magma of Ôshima is, then, most probable. In such fluidal magma, movement of the crystals is by no means a mere speculative process, but must be necessarily expected.

### **Separation of a Mix-Crystal Series.**

Crystallization of the magma of Ôshima involves the separation of mix-crystal series as olivine, plagioclase, and pyroxenes.

BOWEN'S<sup>1)</sup> discussion on the crystallization of melts of any system involving a mix-crystal series under various conditions may be summarized as follows:—

(I) *Crystallization with Perfect Equilibrium*.—Let *A* and *B* be respectively the higher- and lower-melting components of the mix-crystal series. When the cooling of the melt is extremely slow and perfect equilibrium prevails, the crystals first separated from the melt are rich in *A*, but as the cooling proceeds, the crystals, not only those in the act of separating but also those which have previously separated, continually change in composition as a result of the interchange of material between liquid and crystals, becoming richer in *B*. The crystals formed in this manner would be homogeneous throughout.

(II) *Crystallization with Great Undercooling*.—When the cooling of the melt is extremely rapid, the liquid may be undercooled to a certain temperature before crystallization begins, whereupon the crystals of uniform composition (without zonal structure) will separate out.

(III) *Crystallization with Zoning*.—When the cooling is moderately rapid, there may be only a limited opportunity or none at all for a change in composition of the crystals already separated, but the composition of crystals in the act of separating would change toward the enrichment of *B*, so that the resultant crystals would show a zonal structure due to difference in composition varying from one rich in *A* to one rich in *B*. There is a certain rate of cooling which gives maximum zoning, in which case, the outermost zone of the crystal has the composition of pure *B*, whatever the total composition of the original

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1) "The Later Stages of the Evolution of the Igneous Rocks," *Jour. Geol.*, Vol. XXIII., Supplement to No. 8, 1915.

material may have been. With a rate of cooling, somewhat quicker or slower than that which gives maximum zoning, the range of zoning is not so great on account of either a moderate degree of undercooling or a partial adjustment of composition between various zones.

(IV) *Crystallization with Local Collection of Crystals.*—In the foregoing discussion, sinking or floating of the crystals has been left out of consideration. The results as outlined above are to be obtained only when the relative movement of the crystals in the melt from which they are separated is prevented. In the case of slow cooling, if the separated crystals differ from the melt in density, sinking or floating of the crystals would take place whereupon a local collection of them would be accomplished. In this case, in the part where many crystals have accumulated, only a small amount of liquid is available for the interchange of material between liquid and crystals, so that the crystals would not be subject to a continual indefinite change in their composition toward enrichment in *B*, but would remain rich in *A*.

#### **Crystallization of the Component Minerals.**

The separation of the component minerals of our rocks took place in two distinct generations—before and after the extrusion of the magma. The phenocrysts of olivine, plagioclase, hypersthene (and clino-hypersthene), and augite belong to the intratelluric separation, while the groundmass constituents, plagioclase, augite, and magnetite, are of the effusive stage. A discussion on the course of the crystallization of these component minerals follows :—

**Olivine.**—Olivine, which contains no other mineral as inclusion, appears to be the earliest separated mineral.



There is reason for believing that the magma of Ôshima closely matches in density calcic plagioclase crystals (p. 109). Olivine crystals are therefore of much higher specific gravity than the magma from which they were separated; consequently the importance of their subsidence in the highly fluidal magma during the course of crystallization may be reasonably assumed.

Olivine forms a mix-crystal series belonging to Type I of Roozeboom's classification<sup>1)</sup> composed of forsterite ( $\text{Mg}_2\text{SiO}_4$ , the higher-melting component with the melting point  $1890^\circ \pm 20^\circ\text{C.}$ <sup>2)</sup>) and fayalite ( $\text{Fe}_2\text{SiO}_4$ , the lower-melting component). Following the discussions given on pp. 105–106, the net result of the separation and subsidence of olivine crystals, when the magma cools uniformly throughout the whole mass, would be: (1) at a given portion of the magma basin, the earlier the stage is, the richer the olivine crystals there present are in forsterite, and (2) at a given stage, the lower the portion of the magma basin is, the more abundant the olivine crystals are, and the richer they are in forsterite. Thus, there must be a stage where the forsterite-rich crystals are concentrated in the lower portion of the magma basin, and where only a few olivine crystals less rich in forsterite are in the upper portion. If the subsidence of the olivine crystals goes on still further, the upper portion of the magma basin will at last become entirely free from olivine.

The olivine in the lavas rich in this mineral is rich in forsterite,  $(\text{Fe}_2\text{SiO}_4)_{13-19}(\text{Mg}_2\text{SiO}_4)_{87-81}$ ; while that in the olivine-poor lavas is less rich in forsterite,  $(\text{Fe}_2\text{SiO}_4)_{25-30}(\text{Mg}_2\text{SiO}_4)_{75-70}$  (p. 102). This can be explained by supposing that the olivine-rich lavas were

1) HARKER, *The Natural History of Igneous Rocks*, p. 372, 1909.

2) BOWEN and ANDERSEN, "The System  $\text{MgO-SiO}_2$ ," *Am. Jour. Sci.* (4), Vol. XXXVII., p. 487, 1914.

discharged from the lower portion, and the olivine-poor ones from the upper portion of the magma basin.

Moreover, the separation of the olivine crystals from the magma should bring about an excess of silica in the residual liquid. That this inference is justified from observed facts, will be shown elsewhere (p. 120).

**Plagioclase.**—Plagioclase also forms a mix-crystal series of Roozeboom's Type I,<sup>1)</sup> consisting of albite ( $\text{NaAlSi}_3\text{O}_8$ , the lower-melting component with the melting point  $1100^\circ\text{C}.$ ) and anorthite ( $\text{CaAl}_2\text{Si}_2\text{O}_8$ , the higher-melting component with the melting point  $1550^\circ\text{C}.$ ). The positions of both solidus and liquidus were accurately determined and the exact composition of solid and liquid in equilibrium with each other in the binary system became known.<sup>2)</sup>

The crystallization of plagioclase takes place in one of the four manners given on pp. 105–106.

The plagioclase phenocrysts in the rocks of Ôshima show no noticeable zonal structure due to chemical difference, though very faint examples are frequently seen. This fact must be construed as meaning that *the cooling of the magma of Ôshima in the intratelluric stage was extremely slow, approaching the rate required to produce perfect equilibrium.* The crystals with only very faint zoning would be formed also by very rapid cooling, but, if so, the centres of crystallization about which plagioclase is precipitated must have been much more numerous, and the plagioclase crystals accordingly would not be so large as they are.

Such slow cooling as is considered to have prevailed in the magma of Ôshima may have afforded an opportunity for the

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1) DAY and ALLEN, "The Isomorphism and Thermal Properties of the Feldspars," *Carnegie Institution of Washington, Publ. No. 31*, 1915.

2) BOWEN, "The Melting Phenomena of the Plagioclase Feldspars," *Am. Jour. Sci.* (4), Vol. XXXV., p. 583, 1913.

movement of the crystals in the magma; consequently if the plagioclase crystals had differed decisively from the magma in density, the movement of the growing crystals and their local accumulation must have taken place in the magma. The inevitable result would be that the plagioclase crystals in different layers in the magma basin would differ in composition, and accordingly the plagioclase phenocrysts in various lavas would not be uniform in their composition. But when we turn to the plagioclase phenocrysts of the Ôshima rocks, we find that they are calcic bytownite,  $Ab_{15}An_{85}$  or very near to it in chemical composition, throughout all the lavas with the only exception that anorthite ( $Ab_3An_{97}$ ) occurs as phenocrysts in the lavas of Chigasaki<sup>1)</sup> (1a; pp. 89-90). Putting aside for a while this exceptional case,<sup>2)</sup> the fact that all the plagioclase phenocrysts are nearly of the same composition could be realized only if no appreciable movement of the plagioclase crystals had taken place in the intratelluric stage *during the crystallization* of plagioclase. From the above fact, we can here reasonably deduce that *the magma of Ôshima (basaltic magma) closely matches the crystals of calcic plagioclase in density*. This conclusion as to the density of the basaltic magma is noteworthy in connection with Bowen's statement that "laboratory determination of densities of calcic plagioclase crystals and of molten gabbro place them very close together, . . . ."<sup>3)</sup>

The degree of porphyricity with respect to the plagioclase phenocrysts is quite variable, from only slightly to strongly porphyritic, but there is no regularity in the variation which is great even in one flow. Variation in the quantity of the olivine phenocrysts in the lavas can be explained as due to a gravitative

1) 千ヶ崎 or 乳ヶ崎

2) With regard to this exceptional case, an explanation is given later (p. 110).

3) "The Problem of the Anorthositic," *Jour. Geol.*, Vol. XXV., p. 211, 1917.

effect (pp. 107–108). In the case of plagioclase phenocrysts, however, the variation in porphyricity is too irregular to be explained in the same manner, but it may be due in some way to varying conditions at the time of extrusion.

Anorthite phenocrysts in the lava of Chigasaki enclose small crystals of olivine, about  $(\text{Fe}_2\text{SiO}_4)_{.3-.19} (\text{Mg}_2\text{SiO}_4)_{.87-.81}$  in composition (p. 90). This may be interpreted as indicating that *the crystallization of the plagioclase began as early as in the middle of the separation of the olivine crystals when they were still very rich in forsterite*. Such being the case, it is reasonable to consider that there was an opportunity for the sinking of the early formed anorthite crystals in company with the olivine crystals which were separating at the same time, though the anorthite crystals themselves would be very close in density to the magma, and that these accumulated toward the bottom in such a way that no change of composition involving an increase of albite (the lower-melting component) in crystals could be accomplished. The presence of anorthite as phenocrysts in the rock of Chigasaki may be explained as a result of the processes above mentioned. The bytownite phenocrysts in other rocks are considered to be, in the main, of later separation from the less calcic residual liquid after removal of the early formed anorthite crystals.

The results of experimental investigations on the equilibrium of various melts in the system involving the crystallization of the plagioclase show that the residual liquids are always very much richer in albite than the plagioclase crystals with which they are in equilibrium.<sup>1)</sup> If, in the middle of the slow crystallization of

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1) BOWEN, "The Melting Phenomena of the Plagioclase Feldspars," *Am. Jour. Sci.* (4), Vol. XXXV., p. 583, 1913.

BOWEN, "The Crystallization of Naplobasaltic, Haploioritic and Related Magmas," *ibid.*, Vol. XL., p. 161, 1915.

plagioclase, the residual liquid happened to cool very rapidly, it would consolidate into a crystalline mass with composition corresponding to that of the residual liquid, uninfluenced by that of the crystals present in contact with the liquid, there being no opportunity for the adjustment of the equilibrium.

In the rocks of Ôshima crystals of sodic bytownite or labradorite occur as a constituent of the groundmass, and often in a thin layer coating phenocrysts of calcic bytownite. These less calcic crystals are no doubt products formed by the sudden cooling of the residual liquid at the time of extrusion. This indicates that *at the last intratelluric stage the bytownite crystals ( $Ab_{15}An_{85}$  or near to it) were in equilibrium with the liquid in which the less calcic plagioclase was one of the components.*

If the magma had cooled slowly further from this stage in the intratelluric reservoir, the plagioclase crystals would have changed their composition, becoming more sodic than  $Ab_{15}An_{85}$ . On the other hand, if the last intratelluric temperature had been higher, the phenocrystic plagioclase would have remained more calcic. Hence, from the fact that all the plagioclase phenocrysts in the rocks of Ôshima which are considered to have been suspended in the magma have nearly the same composition (near  $Ab_{15}An_{85}$ ), it is inferred that *throughout all the stages in the history of the volcano, so far as represented by the exposed lavas, the magmatic temperature has not changed so much as to affect appreciably the composition of the plagioclase crystals suspended in the magma.* In other words, *the long volcanic history of the pouring out of the observed lavas is represented by a very limited interval in the cooling history of the magma.*

As to the temperature of the magma at this stage, we are able to estimate it roughly from the experimental results with



artificial plagioclases. The temperature at which the crystals  $\text{Ab}_{15}\text{An}_{85}$  are in equilibrium with the residual liquid in the binary system albite-anorthite ( $\text{NaAlSi}_3\text{O}_8 - \text{CaAl}_2\text{Si}_2\text{O}_8$ ) is about  $1470^\circ\text{C}$ ., the composition of the liquid being  $\text{Ab}_{40}\text{An}_{60}$ ; while in the ternary system diopside-albite-anorthite ( $\text{CaMgSi}_2\text{O}_6 - \text{NaAlSi}_3\text{O}_8 - \text{CaAl}_2\text{Si}_2\text{O}_8$ ), it is about  $1250^\circ\text{C}$ ., far lower than in the binary mixture, the composition of the residual liquid being then about 54% of  $\text{Ab}_{30}\text{An}_{70}$  and 46% of diopside. The natural magma is a very complex polycomponent mixture, so that the temperature at which the crystals  $\text{Ab}_{15}\text{An}_{85}$  are in equilibrium with the residual liquid must be far lower than that in the binary mixture. From this it can be asserted that *the intratelluric temperature of the magma of Ôshima at the last stage was decidedly lower than  $1470^\circ\text{C}$ ., and may possibly have been as low as  $1250^\circ\text{C}$ . if not still lower.*

**Pyroxenes.**—Pyroxenes in the rocks of Ôshima are hypersthene (and clino-hypersthene) and augite. From studies on artificial melts<sup>1)</sup> it is expected that pyroxenes may belong to a later crystallization than olivine. In agreement with this, no close association of olivine and pyroxene has been observed, in contrast to the frequent association of olivine and plagioclase,<sup>2)</sup> suggesting that the durations of the crystallization of olivine and pyroxene have not overlapped. Accordingly, it is also inferred that plagioclase preceded pyroxene in beginning the crystallization.

Hypersthene occurs only as phenocrysts and never as the constituents of the groundmass in the Ôshima rocks, indicating that

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1) BOWEN and ANDERSEN, "The System  $\text{MgO-SiO}_2$ ," *Am. Jour. Sci.* (4), Vol. XXXVII., p. 487, 1914.

BOWEN, "The Ternary System Diopside-Forsterite-Silica," *ibid.*, Vol. XXXVIII., p. 207, 1914.

ANDERSEN, "The System Anorthite-Forsterite-Silica," *ibid.*, Vol. XXXIX., p. 407, 1915.

2) A close association of olivine and plagioclase is seen in the Chigasaki lava (p. 90) and in micro-allivalite (p. 98).



its crystallization was restricted only to the intratelluric stage.

Hypersthene phenocrysts are often surrounded by augite crystals in parallel intergrowth. From this it is inferred that augite is a later crystallization product than hypersthene.

Augite is found both as phenocrysts and as a constituent of the groundmass, showing that its separation took place both in the intratelluric and effusive stages.

Summarizing what has been stated above the following conclusion is deduced as the most probable course of crystallization of pyroxenes :—

*The hypersthene crystals began to separate from the magma after the crystallization of olivine was completed and in the middle of the crystallization of plagioclase. The duration of the separation of hypersthene was comparatively short, and after the cessation (?) of its crystallization, augite began to separate and continued to do so even in the effusive stage.*

Pyroxenes form mix-crystal series, and the change in their composition during the course of crystallization is expected to have been accomplished as in the cases of olivine and of plagioclase. The data at hand, however, are insufficient for a discussion on this subject. The only point bearing on it is that in one of the somma lavas, two-pyroxene-basaltic bandaite exposed at Gyôja<sup>1)</sup> (3c; p. 74), the phenocrystic augite has the refractive indices:  $\alpha < 1.6869$   $1.6869 < \beta < 1.6906$   $1.7014 < \gamma$ , while the mineral constituting the groundmass has the refractive indices:  $\alpha < 1.6836 < \beta < 1.6869 < \gamma$  (p. 76). From this, it is imagined that the augite crystals whose refractive indices are  $\alpha < 1.6869$   $1.6869 < \beta < 1.6906$   $1.7014 < \gamma$  would, by a change in chemical composition, approach those whose refractive indices are  $\alpha < 1.6836 < \beta < 1.6869 < \gamma$ , if the crystallization

1) 行者

of augite were to proceed further.

Since the specific gravity of the pyroxene crystals is believed to be much higher than that of the magma from which they were precipitated (p. 109) and the cooling of the magma to have been very slow (p. 108), a sufficient opportunity must be allowed for the sinking of the pyroxene crystals. Pyroxene phenocrysts are very scarce in most of our rocks. This fact was also noticed by YAMASAKI<sup>1)</sup> who regarded it as one of the characteristic features of the rocks of Ôshima. This scarcity of pyroxene phenocrysts is understood when it is considered that most of the Ôshima rocks represent the upper portion of the magma basin from which the heavy pyroxene crystals had been removed by their subsidence effected by gravitation.

**Magnetite.**—Magnetite is, for the most part, a product of the period after the magma was extruded as lavas. The probability of this inference is supported by:—(1) Magnetite occurs only as very small grains constituting the groundmass and never as phenocrysts or as inclusions in other phenocrystic minerals. (2) The form of magnetite varies with the crystallinity of the groundmass; thus, the glassy groundmass of some rocks (for example, the hyalocrystalline part of miharaites, p. 81) is almost free from visible magnetite crystals; in the groundmass with a little higher crystallinity, it disseminates in very fine, often skeletal crystals; while it is in euhedral crystals in the groundmass of high crystallinity. If the magnetite crystals belonged chiefly to the intratelluric separation, they would be found in euhedral forms in every rock, whatever the crystallinity of its groundmass may be.

**Groundmass.**—The groundmass is the product of sudden cooling

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1) "Report on the Volcano Ôshima," *Report Earth. Invest. Com.*, No. 9, p. 50, 1893 (in Japanese).

of the residual liquid after the magma has been extruded as lavas. At such a very rapid rate of cooling as prevailed at the time of consolidation of the groundmass, the liquid crystallizes quickly uninfluenced by the crystals in contact with it, there being little opportunity or none for the adjustment of equilibrium between liquid and crystals and for the sorting of the crystals separating. The composition of the groundmass as a bulk must therefore correspond to that of the residual liquid.

This residual liquid in the magma basin is thought to have been practically constant in composition, since its temperature is supposed to have remained nearly the same throughout the whole volcanic history so far as represented by the observed lavas (p. 111); accordingly it is expected that no very appreciable variation will be seen in the composition of the groundmass of our rocks.

What has been actually observed is in harmony with the above expectation as to the composition of the groundmass, though there is a rather wide variation in its texture—crystallinity, granularity, and fabric—, which may be merely due to varying conditions at the time of extrusion.

A difference has been seen, however, in the composition of the plagioclase microlites in the groundmass, from sodic labradorite to sodic bytownite. This would appear to be at variance with what has been stated above, but it must be recalled that, on the separating out of mix-crystals from the liquid, the composition of these differs according to the proportion of the whole liquid that consolidates as crystals, even if the composition of the original liquid was the same. This may account for the difference in the composition of the plagioclase crystals in the groundmass.

### Summary on the Cooling History of the Magma.

The original magma of Ôshima was basaltic, highly fluidal and nearly equal in density to calcic plagioclase.

The magma proceeded to cool extremely slowly. Its cooling history discussed in the foregoing pages is summarized as follows :—

#### (I) *The First Stage.*

**Olivine.**—The olivine began to crystallize. The first crystals were rich in forsterite, but they had a tendency to change their composition toward enrichment in fayalite, due to the molecular interchange between liquid and crystals. The high specific gravity of olivine crystals, the high fluidity of the magma, and the very slow rate of its cooling collectively afforded ample opportunity for the sinking of the olivine crystals in the magma.

#### (II) *The Second Stage.*

**Olivine.**—The separation and the subsidence of the olivine crystals continued to take place. The early separation of the forsterite rich crystals resulted in the enrichment in fayalite of the residual liquid, accordingly, the later separated crystals became richer and richer in fayalite. The olivine crystals that subsided accumulated toward the lower portion of the magma basin, and the comparatively small amount of liquid there available deterred the crystals from continual indefinite change in composition toward enrichment in fayalite. The crystals therefore remained there rich in forsterite.

**Plagioclase.**—The plagioclase crystals began to separate. The earliest ones were very rich in anorthite. Since they closely match the magma in density, they remained practically suspended in the liquid where their composition became more and more sodic. Some

of the crystals, however, had an opportunity to sink in company with the olivine crystals.

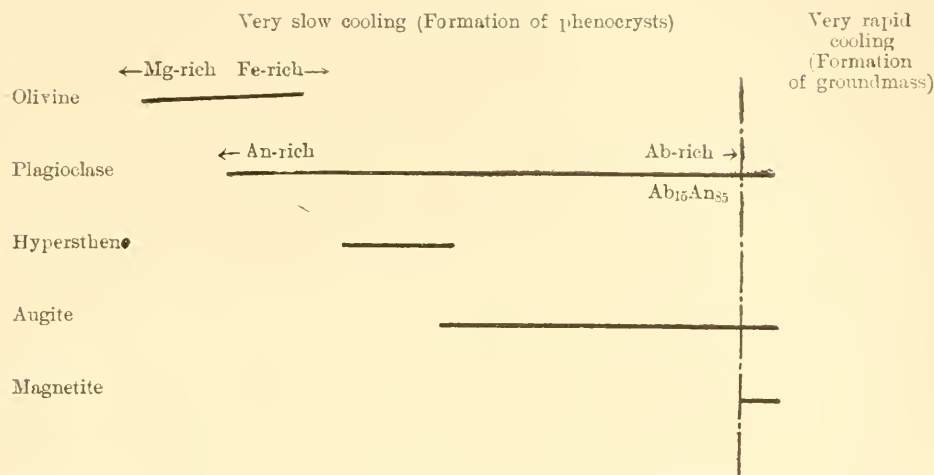


Fig. 40. Diagram showing the order of crystallization.

### (III) *The Third Stage.*

**Olivine.**—The separation of olivine was completed and the later formed crystals comparatively rich in fayalite were in the act of sinking. As a result of the removal of olivine from the magma, an excess of silica was brought about in the residual liquid.

**Plagioclase.**—The plagioclase crystals were separating and their composition was becoming gradually sodic.

**Pyroxenes.**—The crystals of hypersthene appeared, but the duration of their crystallization was brief whereupon augite began to separate. Hypersthene and augite being heavier than the magma, sank in it.

### (IV) *The Last State in the Magma Basin.*

The crystallization of the magma in the intratelluric stage proceeded as above, while the magmatic temperature became deci-



sively lower than  $1470^{\circ}\text{C}.$  and possibly as low as  $1200^{\circ}$ – $1300^{\circ}\text{C}.$  At this stage, bytownite crystals  $\text{Ab}_{15}\text{An}_{85}$  were suspended in the residual liquid.

In *the lower portion* of the magma basin heavy mafic minerals accumulated and also some of the early separated plagioclase crystals which had sunk in company with the olivine crystals. There these minerals remained rich in higher-melting components owing to the small amount of the available liquid.

In *the upper portion* only a few crystals of mafic minerals of later separation, comparatively rich in the lower-melting components, were in the act of sinking.

All the observed lavas of Ôshima belong to extrusions after this last state of the magma was reached. The residual liquid in the magma reservoir consolidated after extrusion as the ground-mass, consisting of plagioclase, augite, magnetite, and a small amount of glass.

### Development of the Various Rock-Types.

The development of the features seen in every rock-type can be explained by supposing that the rocks of different types were extruded from various portions of the magma basin, where differences in amount and character of the heavy intratelluric crystals were effected by gravitative action.

(1) **Rock-Types Comparatively Rich in Phenocrysts of Mafic Minerals.**—Rocks of these types are :—

- (a) Two-pyroxene-olivine-anorthite-basalt (p. 89).
- (b) Olivine-bytownite-basalt  $\alpha$  (p. 92) and  $\beta$  (p. 94).
- (c) Olivine-bytownite-dolerite (p. 93).
- (d) Hypersthene-basaltic bandaite (p. 73).
- (e) Two-pyroxene-basaltic bandaite (p. 74).
- (f) Hypersthene-bearing augite-olivine-bytownite-basalt (p. 76).



The main distinguishing characteristics of these types are: (1) they are comparatively rich in phenocrysts of mafic minerals; (2) the olivine crystals, when present, are richer in forsterite  $(\text{Fe}_2\text{SiO}_4)_{13-19}(\text{Mg}_2\text{SiO}_4)_{87-81}$ , than those in the commonest type of the somma lavas.

These lavas are considered to have been extruded from the lower portion of the magma basin where the heavy crystals accumulated, remaining rich in the higher-melting components owing to the small amount of liquid present. In some of them, phenocrysts of each of the three minerals, olivine, augite, and hypersthene, are present; while in others they are found only singly or in pairs. This may be ascribed partly to there being an opportunity for the separate collection of these minerals, the durations of their crystallization being remote.

As to the occurrence of anorthite phenocrysts in the lava of Chigasaki<sup>1)</sup> (1a), an explanation has already been given (p. 110).

(2) **Common Type of the Somma Lavas** (basaltic bandaite).—This type is characterized by scarcity in phenocrysts of olivine and pyroxenes. Sometimes these are even lacking. When the olivine crystals are present, they are less rich in forsterite than those in the rocks of the preceding types, about  $(\text{Fe}_2\text{SiO}_4)_{25-30}(\text{Mg}_2\text{SiO}_4)_{75-70}$  in composition.

The lavas of this type do not differ from those of the preceding types in the times of their extrusion. They are believed to have come from the upper portion of the magma basin where the later formed crystals comparatively rich in the lower-melting components had sunk halfway. At the time of eruption, these crystals happened to come out by chance with the lava flows. That the distribution of the mafic phenocrysts is very irregular in these lavas and that

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1) 千ヶ崎 or 乳ヶ崎

they are scarce can be explained on the above supposition.

(3) **Central Cone Lavas** (miharaite).—The central cone lavas are entirely free from olivine. These must represent the upper portion of the magma basin in later stages when the subsidence of the olivine crystals in the remaining liquid had progressed so far that they were remote from the extruded lavas.

Pyroxene crystals occur sparingly since they are of later separation than olivine crystals and accordingly their subsidence was less extensive.

In connection with the above proposition that the somma lavas of the common type as well as the central cone lavas originated from the upper portion of the magma basin from which the olivine crystals had subsided, it is a noteworthy fact that chemical analyses made of the rocks of the somma and the central cone (pp. 71 & 85) gave an excess of silica with respect to other oxides, as shown in the following table:—

	Normative quartz	Values of <i>k</i> in OSANN'S formulæ
A	9.6	1.12
B	14.2	1.23
C	6.1	1.02
D	5.3	1.10
E	9.2	1.16
F	8.8	1.15

A ... A typical somma lava exposed on the south shore at the east end of Sashikiji<sup>1)</sup> (2e; Pl. VI. DE 4).

B .. Central cone lava in April, 1912.

C... Central cone lava in October, 1912.

D... Scoria of the central cone in October, 1912.

E ... Central cone lava in December, 1912.

F.... The average of the four B—E.

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1) 差木地

That the early separation of olivine would bring about an excess of silica in the residual liquid was already pointed out on p. 108.

(4) **Micro-allivalite.**<sup>1)</sup>—A small ejected block of micro-allivalite was found imbedded in a volcanic ash bed (Pl. VI. GA 12) intercalated with layers of the lavas of Kazahaya<sup>2)</sup> (1a; p. 92). It is a holocrystalline mass consisting of anorthite  $Ab_6An_{94}$  and olivine  $(Fe_2SiO_4)_{12-18}(Mg_2SiO_4)_{88-82}$  with a small quantity of interstitial matter (p. 99). Both plagioclase and olivine constituting the micro-allivalite belong to the varieties richer in higher-melting components than those in common lavas. This fact is, according to the writer's belief, directly connected with the genesis of this ejected block.

There was a period when only anorthite and olivine (rich in forsterite) were crystallizing from the magma (the second stage, pp. 116–117), so that these had an opportunity of sinking together in the magma reservoir and accumulating in such a manner that no change in their compositions toward enrichment in the lower-melting components could be accomplished owing to the small amount of liquid available for the interchange of material between liquid and crystals. Thus, the mass formed at the lower portion of the magma basin would have just the characters now seen in micro-allivalite. The block now under consideration may be a piece broken off and ejected from the mass formed by the above process at the lower portion of the reservoir.

1) Phanero-crystalline ejecta are very common both in our country as well as abroad, and various views on their geneses have been suggested by different writers. Especially on those from the volcanoes of Japan, we have Hirabayashi's and Fukuchi's studies respectively on those of Fuji ("Report on the Geology of Volcanoes Fuji and Ashitaka," *Report Ethq. Invest. Com.*, No. 24, 1889, in Japanese) and of some of the Idzu Islands other than Ôshima ("On the Phanero-crystalline Bombs from Some of the Idzu Islands," *Jour. Geol. Soc. Tôkyô*, Vol. VIII, No. 95, 1901, in Japanese).

2) 風早

Another fact to corroborate this inference is that it is closely related to rocks of Kazahaya which are believed to have been extruded from the lower portion of the magma basin.

(5) **Augite-micro-diorite.**—This is an ejected block, about 3 *cm.* across, found in an agglomerate bed at the northern foot of Kagamihata<sup>1)</sup> (1c). It is a holocrystalline mass consisting of zonal structured plagioclase ranging from  $Ab_{65}An_{35}$  to  $Ab_{45}An_{55}$ , uncommon augite which is greenish and slightly pleochroic, and acidic interstitial matter with micrographic fabric, with magnetite and apatite as accessory constituents (pp. 99–101).

This is a mere block showing no relation to any lavas, but its petrographic characters are just what might be expected to form at the upper portion of the magma reservoir if the cooling of the magma proceeded at a moderate rate.

As already stated (pp. 117–118) the magma of Ôshima is believed to have reached the stage at which it was in the middle of the crystallization of plagioclase and augite, and the temperature was that at which bytownite crystals  $Ab_{15}An_{85}$  were in equilibrium with the residual liquid. This state of the magma has been maintained throughout the whole volcanic history so far as it is now traceable.

If the cooling of the magma proceeds further from this state at a very slow rate the results would be as follows:—

Plagioclase and augite, which were crystallizing till the above-mentioned state of the magma was reached, would continue to crystallize, and magnetite would soon begin to crystallize. The plagioclase and augite crystals in separating would become richer in the lower-melting components as time goes on. Even the crystals already separated, if there is a sufficient amount of the available

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1) 鏡端

liquid in contact with them, would change their compositions toward enrichment in the lower-melting components. But slow cooling affords a great opportunity for the continual movement of the growing crystals with respect to the residual liquid unless they match the liquid closely in density. The augite crystals being much heavier than the magma, their subsidence in it is beyond dispute. The plagioclase crystals are nearly equal in density with the magma, so that they must remain suspended in the liquid and accomplish a change in composition, becoming more and more sodic. In the meantime, the separation of these crystals would bring about in the residual liquid a relative concentration of silica (pp. 108 & 120-121) and the liquid would become gradually lighter as crystallization proceeded and at last decisively lighter than the plagioclase crystals. Then the plagioclase crystals hitherto suspended would begin to sink.<sup>1)</sup>

If the cooling of the magma is rather more rapid, the sinking of the crystals would be somewhat restricted. In this case the plagioclase which does not differ much from the surrounding liquid in density would have only a limited opportunity for sinking, and the zoning of plagioclase would result. The augite crystals being heavier than the plagioclase crystals, the former would subside from the liquid in the upper portion before the newly separated crystals could deposit around them, so that the augite crystals in the upper portion would be only those rich in lower-melting component. Then the resultant mass would consist in the upper parts mainly of zonal structured plagioclase, lower-melting augite, and magnetite, with the latest crystallization product as the interstitial matter.

In our micro-diorite; the plagioclase is from labradorite to

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1) Such a process was supposed also by Bowen when he discussed the anorthosites (*Jour. Geol.* Vol. XXV., p. 213, 1917).



andesine with zonal structure; the interstitial matter is acidic micrographic material, and the augite is of an unusual type. If this augite is interpreted to be one rich in lower-melting component, then the petrographic characters of the micro-diorite are just those which might be expected to be formed by the above mentioned process from the residual liquid of the magma of Ôshima when cooling at a moderate rate.

From what has been said, the genesis of the micro-diorite may be as follows:—

The magma of Ôshima cooled at a moderate rate in some portion of the reservoir and proceeded to crystallize following the course mentioned above, and consolidated into a mass with petrographic characters as seen in micro-diorite. The block now under discussion is a fragmented piece of this mass, which was ejected at the time of eruption.

By the above, the development of the general features of the micro-diorite can be accounted for; but to explain some of the more minute features, further assumptions are necessary.

That the zoning of plagioclase is not always simple in that calcic and sodic plagioclases often occur in alternate zones (p. 99) may be ascribed to a temporary rise of temperature due to the heat evolved by crystallization in the course of cooling of the magma.

As already stated, the absence of zonal structure in the augite crystals in contrast to the noticeable one in the plagioclase crystals may be due to the former outstripping the latter in their sinking down. In spite of this process the augite crystals are not very much inferior to the plagioclase crystals either in size or in amount. This may be explained by supposing that the augite crystals grew more rapidly than the plagioclase crystals. This supposition is



necessary also to explain that the interstitial matter of the latest crystallization is strongly salic, for otherwise it must be far more femic.

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In concluding the present chapter, the writer will remark on the change in the composition of the magma which is expected to be brought about by the cooling. All the rocks of Ôshima represent only one stage of the cooling of the magma, so that the difference between the various rock-types does not correspond to the difference in the course of cooling. The cooling history can only be inferred from the observed features of the component minerals. The past course of the magmatic change was summarized on pp. 116–118. The salic interstitial matter in the micro-diorite suggests the future state of the residual liquid after the cooling of the magma has proceeded sufficiently far. Summarizing, it is seen that the composition change of the local magma due to cooling would be from basic to acidic.

#### IV. The Geologic Position.

Nearly along the meridian of  $138^{\circ}\text{E.}$ , an important tectonic line—the so-called “fossa magna” or “Fuji line”—traverses the main island of Japan, or Honshû, dividing it into two tectonically very distinct halves, North and South Japan. The line is prolonged in the direction of  $\text{S. } 10^{\circ} \text{ E.}$ , being represented by a submarine ridge with a depth of less than 1,000 *m.* in the deep of the Pacific Ocean. To the east of this ridge a trench runs parallel with it, to which it may be genetically related (Fig. 41).

Ôshima rests on the above-mentioned submarine ridge with the other members of the Idzu Islands—Toshima, Udoneshima, Nijima,<sup>1)</sup>

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1) 利島 鵜渡根島 新島

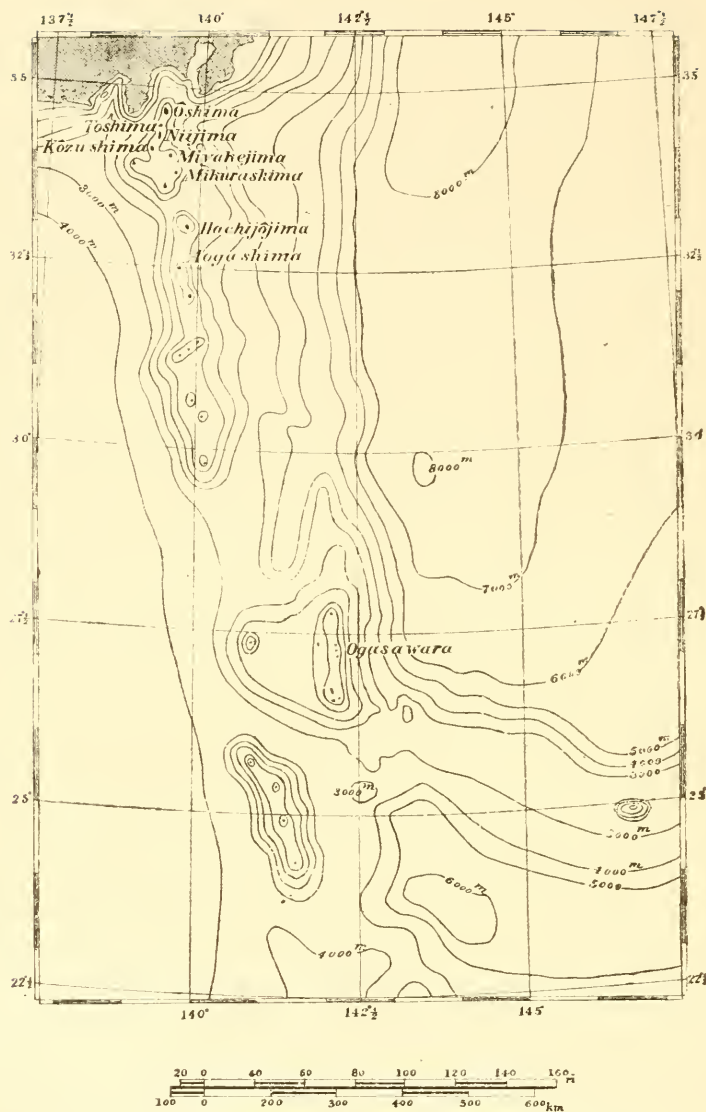


Fig. 41. Bathymetric map of the environs of the Idzu islands.

Shikineshima, Kôzushima, Miyakejima, Mikurashima, and Hachijôjima.<sup>1)</sup> All of these islands are volcanic, and are grouped by some as belonging to the "Fuji volcanic chain."

1) 式根島 神津島 三宅島 御蔵島 八丈島

This term "Fuji volcanic chain" has, however, been variously defined by different authors. In its widest sense it includes all the volcanoes along the above-mentioned tectonic line, starting from the Myôkô<sup>1)</sup> volcanic group, passing through Yatsugatake<sup>2)</sup>, Fuji<sup>3)</sup>, Ashitaka<sup>4)</sup>, Hakone<sup>5)</sup>, and then through the volcanoes of the Idzu peninsula and the insular and submarine volcanoes of the Pacific—Shichitô<sup>6)</sup>, Ogasawara<sup>7)</sup>, Sulphur Islands, etc,—to the Mariana Islands. These volcanoes are arranged linearly in the same way as those belonging to one volcanic chain, but petrographically the nature of their lavas is indefinite, being variously represented by many kinds of rocks, and the forms of the volcanoes are multifarious<sup>8)</sup>; accordingly it is doubtful whether all of these volcanoes can be reasonably grouped in one volcanic chain. Putting aside for a while a general discussion on the problem of the so-called "Fuji volcanic chain" as a whole, the volcanic lineage of the Idzu islands will be first considered so far as this directly bears on the geologic position of Ôshima.

The insular volcanoes of Idzu are to be divided into two groups in their arrangement and morphographic features, as well as in the nature of the rocks which constitute them. Ôshima, Toshima, Udoneshima, Miyakejima, Mikurashima, and Hachijôjima arrange in the direction N.N.W.—S.S.E. and are conical (homate or konide), being built up of basaltic rocks; Nijima, Shikineshima, and Kôzushima arrange in N.N.E.—S.S.W., to the west of the former group and are flat with comparatively steep sides in their forms (tholoids), being constituted of rhyolitic rocks.

That the Idzu islands should be classed in two groups was suggested by YAMASAKI<sup>9)</sup> as early as in 1896, for he stated that

1) 妙高 2) 八ヶ嶽 3) 富士 4) 愛鷹 5) 箱根 6) 七島 7) 小笠原

8) B. Kotô, "The Volcanoes of Japan," *Jour. Geol. Soc. Tôkyô*, Vol. XXIII., p. 6, 1916.

9) "Report on the Volcano Ôshima," *Report Eartly. Invest. Com.*, No. 9, 1896 (in Japanese).

there are two branches in what is commonly called "the Fuji volcanic chain"—one comprising the volcanoes of basic rocks as Ôshima, Miyakejima, Hakone<sup>1)</sup>, etc. and the other including those of the acidic rocks as Niijima, Kôzushima<sup>2)</sup>, etc. having a close relation to the dacitic volcanoes of the Idzu peninsula; and that the recent activity of some of the former is known, while of the latter there are, according to him, no historic records of eruptions.

Later, in 1902, FUKUCHI<sup>3)</sup> gave a fuller account on the distinction between these two groups of insular volcanoes. He considered that the basaltic islands belong to the same volcanic system as the volcanoes of Fuji, Hakone, Amagi<sup>4)</sup>, etc. which are constituted of similar rocks, and to this group of volcanoes he confined the application of the term "Fuji volcanic chain," excluding the rhyolitic islands. As to the age relation between these two groups of volcanoes, he supposed that the rhyolitic islands are older than the volcanoes of "the Fuji chain." He was led to this belief by the fact that basaltic ejecta cover the rhyolitic rocks at the northern part of the island Niijima, and that the rhyolitic rocks of the Idzu islands are correlative to similar rocks at the southern extremity of the Idzu peninsula which are of the Tertiary period.

FUKUCHI's view on the age relation between the rhyolitic and basaltic islands was later endorsed by TAK. KATÔ<sup>5)</sup>. KÔZU<sup>6)</sup> also pointed out that the rhyolitic rocks of the Idzu islands are petrographically similar to the plagioliparite of the middle Tertiary which occurs in the southern part of the Idzu peninsula.

1) 大島 三宅島 箱根

2) 新島 神津島

3) "Geology of Niijima," *Report Earthq. Invest. Com.*, No. 39, 1902 (in Japanese).

4) 天城

5) "The Land Slides in Kôzushima," *Report Earthq. Invest. Com.*, No. 63, 1909 (in Japanese).

6) "Geology of the Southern Part of the Idzu Peninsula," *Jour. Geol. Soc. Tôkyô*, Vol. XIX, p. 97, 1912 (in Japanese).

Thus, the previous writers agree on the time relation between the rhyolitic and basaltic islands, and are inclined to consider, with varying emphasis, that the former are older than the latter, being correlative to the Tertiary rhyolitic bodies in the Idzu peninsula.

The sequence of the lavas as above being harmonious with that in North Japan, where pre-andesitic vulcanism is represented by plagioliparite mostly of the Tertiary period<sup>1)</sup>, the above view has been generally admitted by geologists.

Very recently, TSUJIMURA<sup>2)</sup> opposed this generally accepted view. He noticed that Niijima and Kôzushima are too young in their morphographic aspect to be Tertiary volcanoes, and came at last to doubt if they are really so old as has been generally supposed.

On the other hand, ÔMORI and NAKAMURA enumerate in their historic records volcanic eruptions which they consider to mean those of Kôzushima in 838<sup>3)</sup> and of Niijima in 886<sup>4)</sup>.

1) B. Kotô, "Volcanoes of Japan," *Jour. Geol. Soc. Tôkyô*, Vol. XXIII, p. 5, 1916.

2) "Kôzushima and Niijima," *Report Earthq. Invest. Com.*, No. 89, 1918 (in Japanese).

3) Zoku-Nihon-Kôki (續日本後記) records that from August 15, 838 (承和五年七月癸酉十八日) for more than two months, some minute powders like ash fell in the provinces of Kawachi, Mikawa, Tôtômi, Suruga, Idzu, Kai, Musashi, Kazusa, Mino, Hida, Shinano, Echizen, Kaga, Etchû, Harima, and Kii. Some authors consider this as an eruption of Ôshima, while ÔMORI pointed out that this must mean an eruption of Kôzushima for in the same book are found the following lines:—

承和七年九月。伊豆國言。賀茂郡有造作島。本名上津島。……上津島本體。草木繁茂。東南北方巖峻嵒崿。人船不到。纔西面有泊宿之濱。今成燒崩。與海共成陸地并沙渚。二千許町。其島東北角。有新造神院。其中有壘。高五百許丈。其周八百許丈。其形如伏鉢。……自餘雜物。燎燄未止。不能具注。去承和五年七月五日夜出火。上津島左右海中燒。炎如野火。十二童子相接取炬。下海附火。諸童子履潮如地。入地如水。震上大石。以火燒摧。炎燭達天。其狀朦朧。所々燄飛。其間經旬。雨灰滿都。

"上津島" in the above description must mean Kôzushima (神津島); "西面有泊宿之濱" corresponds to the village, Kôzushima-mura, on the west coast of the island; and "其島東北角。有新造神院。其中有壘。高五百許丈。其周八百許丈。其形如伏鉢。" is a description of Tenjô-yama (天井山) standing at the northeastern part of the island.

4) Sandai-jitsuroku (三代實錄) records that on July 3, 886 (仁和二年五月十四日), there was observed in the province of Awa, toward the south, a very thick dark cloud, in which lightning flashes were seen, thurdeing noises and earthquakes continuing all night. The sky did not clear up till the morning of July 5 (五月二十六日), when the earth was covered with ashes two or three inches thick. On the other hand, it is told, according to Nihonkiriyaku (日本紀略) and Fusôryakki (扶桑略記), that in 887 the provincial government of Idzu presented the central



Thus, the almost settled opinion as to the age relation between the rhyolitic and the basaltic Idzu islands has become doubtful, and an interesting problem, which is of first importance in the geology of the Idzu islands, has presented itself for study.

It is true that the basaltic islands afford many records of recent eruptions, among which those of Ōshima in 1876-'77 and in 1912-'14, and of Miyakejima in 1874 are still fresh in our memory; while the rhyolitic islands have not erupted, at least in very recent times. But it is problematical whether the rhyolitic islands are really so very old as has been hitherto generally supposed and whether their activity had been brought to an end before the basaltic ones appeared.

In the summer of 1918, the writer visited Niijima, one of the rhyolitic islands, with the object of solving the above question if possible. The following is only a very brief statement on this particular problem.

The rhyolitic rocks of Niijima are readily grouped in three main types—pyroxene-rhyolites<sup>1)</sup>, hornblende-rhyolites, and biotite-rhyolites, in order of extrusion. Besides these there is in the north of the island a basaltic ejecta bed which caps the masses of pyroxene- and hornblende-rhyolites. It is this fact which led FUKUCHI to the conclusion that the rhyolitic islands are older than the basaltic ones. This fact, however, only indicates that the

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government with a map of a newly created island, and so NAKAMURA considered that the record of the eruption above cited probably related to this new island. Unfortunately the name of the island is not stated, but from the descriptions “神明宮火以潮所燒則如銀岳,” ŌMORI and NAKAMURA are inclined to consider this as meaning an eruption in a rhyolitic island, probably in Niijima, for “銀岳”, or the “silver mountain”, may mean white rhyolitic mountain.

1) Here the rocks are called under the field names. The rocks of Niijima were described by FUKUCHI (“Geology of Niijima,” *Report Earthq. Invest. Com.*, No. 39, 1902) as “rhyolites”; while BACHER (“Über die Laven der kleineren Idzu Inseln,” München, 1914) pointed out that they are “dacites” and not “rhyolites”, as they contain no sanidine. The rocks are very low in crystallinity so that to what rock species they belong cannot be determined by microscopic investigation only.



ejection of the basaltic blocks took place after the extrusion of the particular lavas of pyroxene- and hornblende-rhyolites that constitute the masses underlying the basaltic ejecta, and not necessarily that all the rhyolitic rocks are older than the basaltic rocks. On the contrary the ejection of the basaltic blocks seems to have been antecedent to the extrusion of the biotite-rhyolites. For, while this basaltic ejecta bed also contains a few blocks of pyroxene- and hornblende-rhyolites, none of biotite-rhyolites are known to be imbedded; and it is also not known that the basaltic ejecta cover a biotite-rhyolite mass. Moreover, the rhyolitic ejecta bed, "Shiromama" bed, bears a few basaltic blocks among others. The homatholoid of Mukaiyama<sup>1)</sup> of biotite-rhyolite in the south of the island rests on the "Shiromama" bed, and shows a very young morphographic aspect. Thus, it has become clear that rhyolitic and basaltic vulcanism displayed activity alternately in Niijima, accordingly at least some of the rhyolitic rocks must be as young as the basaltic ones.

All the rhyolitic bodies in Niijima, even the oldest, show far younger morphographic features than those on the main land, and the rocks constituting the former are very fresh with no trace of alteration in contrast to the more or less altered nature of the rocks of the latter; thus the volcanic activity of rhyolites in Niijima seems to have begun far later than that in the Idzu peninsula. Tradition, indeed, speaks of an eruption of Mukaiyama that occurred about 800 years ago. Oral tradition does not constitute very strong evidence, but here it must be noticed that tales of the eruption are told only of the newest volcano and not of the others, which makes us consider the tradition in this case all the more credible.

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1) 向山

Kôzushima also shows very young morphographic features. There is no good reason for doubting that the record on the vulcanism in 838 (see the foot-note on p. 129) refers to the eruption in Kôzushima.

From the above the rhyolitic insular volcanoes in Idzu appear to be quite young, and it is very probable that their eruptions took place even in historic times.

It will not be out of place here, to call attention to the geology of the Idzu peninsula which is closely related to that of the Idzu islands, for it is necessary in discussing the geology of isolated districts to correlate them with the geologically connected main land.

The geology of the Idzu peninsula was studied by ISHIWARA<sup>1)</sup>, and the southern part in particular by Kôzu<sup>2)</sup>. The present writer also had an opportunity of making a hasty journey through the peninsula in January of 1918, and to secure some acquaintance with the rocks there exposed. The time available, however, was too limited for more than an observation confined only to a few parts along the eastern shore and the small area near Shimoda<sup>3)</sup>.

So far as is known to the writer principally from books and only to a limited extent from brief personal observation, the geology of the Idzu peninsula is as follows:—

The peninsula is built up largely of volcanic rocks. According to Kôzu, the rocks constituting the southern part of the peninsula are, in the order of their eruption: plagioliparite, potash-liparite, propylite, liparite, dacite, and pyroxene-andesite; all but potash-liparite accompanying the tufts and breccias besides the solid lavas. In his opinion the extension of these rocks began in the

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1) "Volcanoes in the Idzu Peninsula," *Report Earthq. Invest. Com.*, No. 17, 1898 (in Japanese).

2) "The Geology of the Southern Part of the Idzu Peninsula," *Report Imp. Geol. Surv.*, No. 38, 1913 (in Japanese).

3) 下田

middle Tertiary and lasted toward the end, with repeated renewal and decay in activity.

How these rocks are magmatically related to one another is a matter needing further investigation, yet it seems but natural to consider them as of two distinct lineages—rhyolitic and andesitic. It is to be noted that *the rocks of these two lineages erupted alternately in the Idzu peninsula in the Tertiary period.*

This order of eruption of these two rock-types being very important, the writer made a special point of confirming it during his trip. The youngest pyroxene-andesite covering the other rocks is seen in almost every part of the peninsula. There is, besides this, an older pyroxene-andesite underlying a liparitic rock. This older andesite was included by Kôzu in his "propylite" though the rock is, as he himself says, sometimes quite fresh. The age relation of this older andesite to a liparitic rock was observed by the present writer at two localities: near Nagata<sup>1)</sup>, a small village 4 km. (or 1 ri) northeast of Shimoda, where a liparitic tuff bed containing blocks of pyroxene-andesite was seen; and at the boundary of Asahi-mura<sup>2)</sup> and Chikuma-mura<sup>3)</sup>, on the north side of the main road that runs westward from Shimoda through Kisami<sup>4)</sup>, where an altered andesitic rock is overlain by a bed of liparitic tuff some 4 m. thick.

Of the andesitic and rhyolitic rocks, the former continued to extrude in the Quaternary period in the Idzu peninsula and its environs. The Quaternary volcanoes, Amagi, Ashitaka, Fuji, Atami, Hakone<sup>5)</sup>, etc., are all built up of rocks belonging to the andesitic lineage which are considered to have descended from the Tertiary andesitic rocks of the southern part of the Idzu peninsula.

As a whole, the nature of the lavas of these volcanoes appears

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1) 長田    2) 朝日村    3) 竹蔭村    4) 吉佐美    5) 天城 愛鷹 富士 熱海 箱根

to have changed along the line from acidic to basic as time passed. Thus, according to ISHIWARA<sup>1)</sup>, the main body of Amagi<sup>2)</sup>, a volcano of the early Diluvium, consists of rather acidic "pyroxene-andesite" with 61% of SiO<sub>2</sub>, while its parasitic cones which were formed in the late Diluvium are constituted of "basalt" with 56% of SiO<sub>2</sub>.<sup>3)</sup> HIRABAYASHI<sup>4)</sup> also concluded that the lavas became more and more basic, not only locally but also regionally: from "pyroxene-andesite" to "olivine-pyroxene-andesite" in the volcanoes Hakone, Atami, and Ashitaka<sup>5)</sup>, and from "olivine-pyroxene-andesite" to "plagioclase-basalt" with 50% SiO<sub>2</sub> in the volcano Fuji<sup>6)</sup>.

On examining the rocks of the andesitic lineage in the peninsula and its environs, it is seen that their petrographic characters approach more and more to those of the basaltic rocks of the Idzu islands in the course of time, while the lavas of Fuji, Ômuroyama<sup>7)</sup>, etc. bear a close resemblance to those of the basaltic insular volcanoes. It may be reasonably concluded, therefore, that the basaltic Idzu islands belong to the same volcanic lineage as the above-mentioned volcanoes in the main land, and that their lavas descended from the Tertiary andesitic rocks of the southern part of the Idzu peninsula.

On the other hand, the rhyolitic rocks are not known to have erupted in the Idzu peninsula in the post-Tertiary period. But the rocks of the rhyolitic Idzu islands are of the same petrographic lineage as those of the rhyolitic bodies in the main land, as already suggested by some previous writers; and their extrusion took place, in all probability, even in historic times. It appears then that

1) "Volcanoes in the Idzu Peninsula," *Report Earthq. Invest. Com.*, No. 17, 1898 (in Japanese).

2) 天城

3) B. KOTŌ, "Studies on Some Japanese Rocks," *Quarterly Journal of Geological Society*, Vol. XL, p. 451, 1884.

4) "Volcanoes Fuji and Ashitaka," *Report Earthq. Invest. Com.* No. 24, 1899, (Japanese).

5) 箱根 熱海 愛鷹    6) 富士    7) 大室山

the rhyolitic rocks of the Idzu islands must have descended from those of the Tertiary period in the Idzu peninsula.

As stated above, the insular group of Idzu comprises volcanoes of two different lineages—those of basaltic and rhyolitic rocks, descended respectively from the Tertiary andesitic and rhyolitic in the Idzu peninsula. The writer hereafter distinguishes these two groups of the volcanic islands as “*Ôshima group*” and “*Niijima group*.” In the age of the volcanic activity of these two groups there is no disparity, all the volcanoes being very young. Of these, the basaltic Toshima, Udoneshima, and Mikurashima<sup>1)</sup>, and the rhyolitic Shikineshima<sup>2)</sup> are not known from historic records to have ever been in a state of eruption; while the basaltic Ôshima, Miyakejima, and Hachijôjima<sup>3)</sup>, and the rhyolitic Niijima and Kôzushima<sup>4)</sup> have displayed activity in historic times.

The islands of the Ôshima group and the volcanoes Fuji, Ashitaka, Hakone, Amagi, Atami, etc. lie in the zone that trends in the direction N.N.W.—S.S.E., meeting the festoon islands at large angles, and on its southern prolongation the volcanoes Aogashima, Torijima, and Sulphur Islands<sup>5)</sup>, as well as the submarine ones near Bayonnaise Rocks, Smith Rocks, North and South Sulphur Islands, etc. are situated. All of these are young volcanoes with historic records of eruptions, and their lavas are auganitic or basaltic. The writer thinks it appropriate to define the term “Fuji volcanic chain” as meaning this row of the Quaternary auganitic and basaltic volcanoes.

The insular volcanoes of the Ôshima group form a sub-group in the Fuji volcanic chain in geographic contiguity, petrographic and morphographic resemblance (all konide or homate), and similarity in mode of eruption. Of the volcanoes in the main

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1) 利島 鵜渡根島 御藏島    2) 式根島    3) 大島 三宅島 八丈島  
4) 新島 神津島    5) 青ヶ島 鳥島 硫黄島



Table I.

Abbreviations.

Lab. .... labradorite.      Byt. .... bytownite.      An. .... anorthite.  
 + ..... present.      — ..... absent.      ± ..... sometimes present, sometimes absent.

	Óshima			Toshima			Udoneshima		Miyakejima			Yikurashima			Sambon- dake	Fuji
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Pheno- crysts	Byt.	Byt.	Byt.	Lab. to Byt		Byt.	Lab. to Byt	Byt.	Byt.	An. Byt.		Byt.	An.	Byt.		
	±	±	±	+	+	+	+	—	+	+	+	+	—	+	+	±
	±	+	±	—	—	+	—	—	—	—	—	—	—	—	+	±
	±	—	+	+	+	+	+	+	+	+	—	—	—	+	+	+
	—	—	—	+	—	—	—	—	—	—	—	—	+	—	+	—
Magnetite	—	—	—	—	—	—	—	—	—	—	—	+	+	+	+	±
Consisting chiefly of plagioclase, augite, magnetite, and glass.																
Groundmass	53.01	51.45		49.91			50.79		54.55	53.35						49.77
SiO <sub>2</sub>	14.73	16.84		18.13			16.61		16.23	15.62						20.57
Al <sub>2</sub> O <sub>3</sub>	3.38	1.49		3.87			6.96		4.07	4.21						6.06
Fe <sub>2</sub> O <sub>3</sub>	9.42	10.95		5.48			3.51		8.02	8.12						5.11
FeO	4.97	4.48		6.16			7.63		3.66	4.44						5.00
MgO	9.09	10.71		9.90			10.03		8.91	9.68						10.37
CaO	2.09	1.23		2.33			2.58		2.44	2.18						1.08
Na <sub>2</sub> O	0.44	0.37		0.37			0.55		0.32	0.84						0.84
K <sub>2</sub> O	1.22	0.72		2.78			0.38		0.29	0.40						0.73
H <sub>2</sub> O	1.03	1.27		0.87			1.01		1.19	1.18						—
TiO <sub>2</sub>	0.04	—		—			—		—	—						—
ZrO <sub>2</sub>	0.34	0.19		—			—		—	—						0.20
MnO <sub>2</sub>	0.11	0.26		—			—		—	—						0.16
P <sub>2</sub> O <sub>5</sub>	—	—		—			—		—	—						—
CO <sub>2</sub>	—	—		trace			0.19		0.24	trace						—



<i>s</i>	58.1	56.8	56.1	54.8	60.3	58.6		54.8
<i>A</i>	2.5	1.6	2.8	3.0	2.8	2.9		1.7
<i>C</i>	6.8	9.2	9.1	7.3	7.7	7.1		11.6
<i>F</i>	23.2	21.7	21.4	24.8	19.3	22.2		18.6
<i>a</i>	1.5	1.0	1.7	1.7	1.9	1.8		1.1
<i>c</i>	4.2	5.6	5.7	4.3	5.2	4.5		7.1
<i>f</i>	14.3	13.4	12.6	14.0	12.9	13.7		11.8
<i>n</i>	8.7	8.3	9.1	8.8	9.3	8.0		6.5
<i>k</i>	1.1	1.2	1.0	1.0	1.2	1.1		1.1
<i>Q</i>	9.6	8.8	4.3	4.4	13.4	9.6		9.1
<i>Or</i>	2.8	2.2	2.2	3.3	1.7	5.0		5.0
<i>Ab</i>	17.8	10.5	19.9	22.0	20.4	18.3		8.9
<i>An</i>	29.2	39.2	37.8	32.0	32.0	30.4		48.4
<i>Di</i>	12.4	10.3	9.1	13.8	8.0	14.6		2.0
<i>Hy</i>	19.7	23.2	16.4	12.7	14.6	13.4		16.2
<i>Mt</i>	4.9	2.1	5.6	8.4	5.8	6.0		8.8
<i>Il</i>	2.0	2.4	1.7	1.9	2.3	2.3		—
<i>Ap</i>	0.3	0.6	—	—	—	—		—
<i>Hm</i>	—	—	—	1.2	—	—		—

## Ôshima.

1) The somma lava (basaltic bandaitc).

2) The central cone lava (militarite).

3) The rocks of the northwestern small igneous bodies (basalt &amp; dolerite).

## Toshima.

4) } Specimens from 60m. (Olivine-bearing feldspar-basalt.

5) } from the top. Ditto.

6) } Hyperssthene-basalt.

## Udoneshima.

7) } Localities not mentioned (olivine-bearing feldspar-basalt).

8) }

## Miyakejima

9) A specimen from the top (augite-andesite).

10) } Olivine-bearing feldspar-basalt.

11) } Lava of 1874. { Hyperssthene-basalt in transition to hypersthene-andesite.

## Mikurashima.

12) } Feldspar-basalt.

13) } Localities not mentioned. { Basalt.

14) } Olivine-bearing feldspar-basalt.

## Sambondake.

15) Hyperssthene-bearing basalt.

## Fuji.

16) Plagioclase-basalt, partly olivine-pyroxene-andesite. The chemically analysed specimen was collected at the crater.



land, Fuji is most closely related to those of the Ôshima group in all respects. These volcanoes appear to form one petrographic province, and their lavas are closely comagmatic. In the accompanying tables (Tables I & II), the petrographic characters of the lavas and the time distribution of the outbursts in historic times of these and the related volcanoes are shown.

As to the birth-time of the volcanoes of the Ôshima group, the writer has been led, by correlating their lavas with the general course of change in the magma of andesitic lineage in the Idzu peninsula (pp. 133-134), to think that they might have been born at a late date, probably in late Diluvium, when the nature of the magma regionally became strongly basic. Structural and morphographic features of these volcanoes also suggest that they are very young. The injection of the basic magma appears to have been the first step in the igneous activity of the basaltic Idzu islands, and these insular volcanoes may have been formed on the injection fissure at the locations where the lava extrusion was specially favourable.

The above is the writer's present assumption as to the geologic position of Ôshima but it must be subject to further study.

In concluding this chapter the writer wishes briefly to remark on the data so far known concerning the bathymetric conditions of the environs of Ôshima (Fig. 42). The sea bottom near the island slopes outwards from it in all directions, steeply toward the north and east<sup>1)</sup>, and gently toward the south and west. A sea over 800 fathoms (about 1,500 m.) deep separates the island from the Bôsô<sup>2)</sup> peninsula consisting chiefly of the

---

1) How long the belt of this steep slope is prolonged is not known, but the bathymetric map suggests that it runs in the direction S. by E. nearly in a straight line. It may perhaps have some geotectonic meaning such as folding or fault.

2) 房總半島

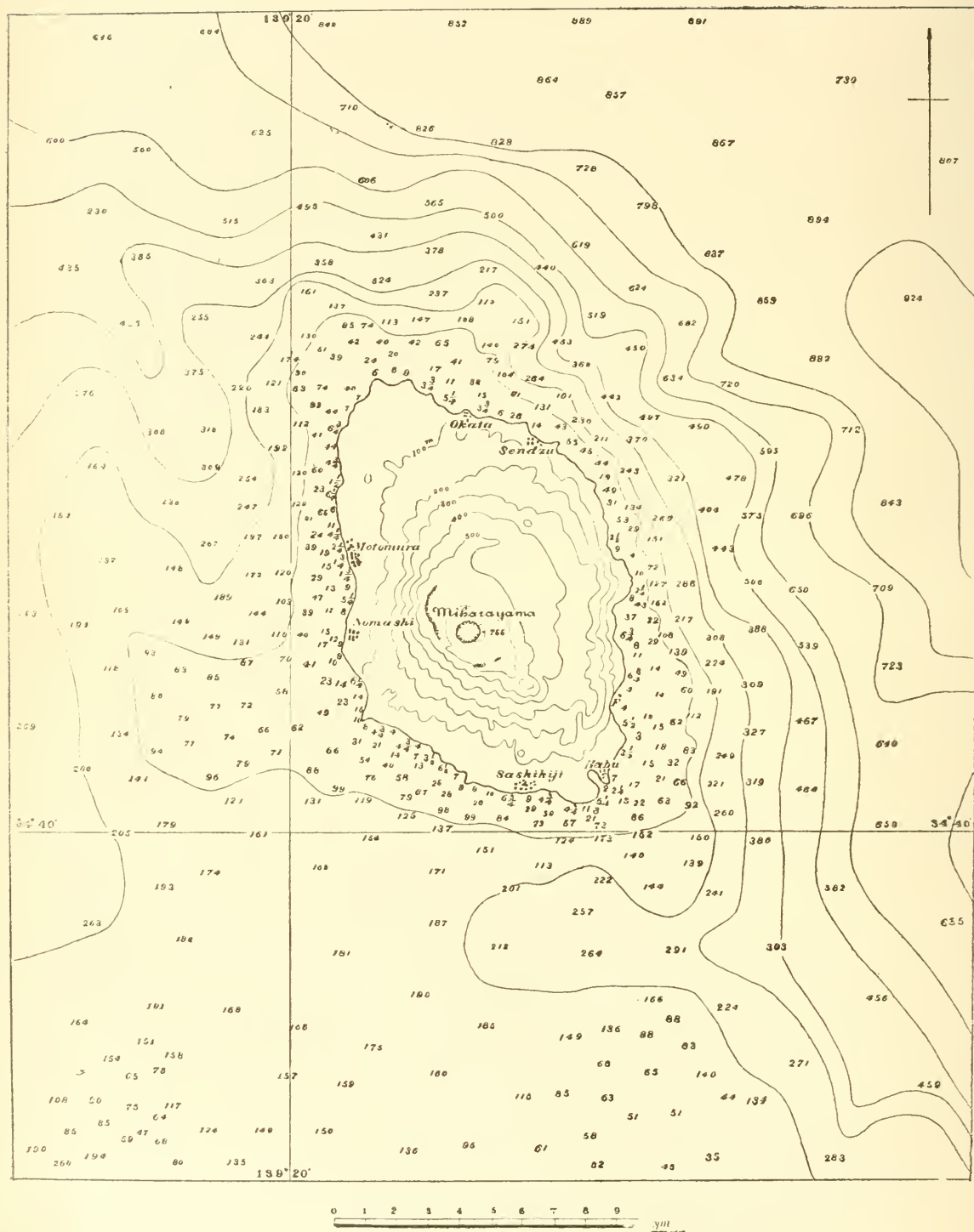


Fig. 42 Bathymetric map of the environs of Ôshima (after Naval Chart of Hydrographic Office Imperial Japanese Navy). Soundings in fathoms.

Tertiary sedimentary rocks, while a shallow floor under 300 fathoms (550 m.) connects the island to the Idzu peninsula which owes its existence to volcanic action. The materials which constitute the sea bottom near Ôshima are, according to YAMASAKI<sup>1)</sup>, fragments of volcanic glass with abundant microlites, pumices, and fine pieces of pyroxenes, and feldspars, mingled with the remains of Foraminifera, Radiolaria, etc., appearing in the main as green mud.

## VII. General Summary.

(1) Both the position now occupied by the Idzu peninsula and its environs have been the scene of volcanic agitation since the Tertiary period. Here the vulcanism of the two different petrographic lineages—andesitic and rhyolitic—have displayed their activity, and built up the Idzu peninsula.

Lavas of these two lineages continued to be extruded down to the Quaternary period. The andesitic or basaltic lavas built up the volcanoes Fuji, Ashitaka, Hakone, Atami, Amagi<sup>2)</sup>, etc. on the main land and many insular and submarine ones in the Pacific Ocean, along the line that runs in the direction N.N.W.—S.S.E., conforming to the conspicuous “Fuji volcanic chain.” The lavas descending from the Tertiary rhyolitic rocks formed the rhyolitic islands off the Idzu peninsula to the west of this volcanic chain. Contrary to the general opinion the writer agrees with TSJIMURA that these rhyolitic islands are as young as the volcanoes of the Fuji volcanic chain.

What is commonly called “Idzu Shichitô”<sup>3)</sup> comprises the

1) “Geology of the Bottom of the Pacific Ocean between the Tôkyô Bay and Ogasawara,” *Jour. Geol. Soc. Tôkyô*, Vol. XV., pp. 382-383, 1908 (in Japanese).

2) 富士 愛鷹 箱根 熱海 天城

3) 伊豆七島

Quaternary insular volcanoes of both of the above-mentioned lineages, and is to be subdivided into the Ôshima group and the Nijima group, consisting respectively of basaltic and rhyolitic islands.

The members of the former group are Ôshima, Toshima, Udoneshima, Miyakejima, Mikurashima, and Hachijôjima.<sup>1)</sup> The rocks of these volcanic islands show a very strong resemblance to one another and appear to be closely comagmatic. By correlating these rocks and those in the related region in the main land, where the general magmatic change is from acidic to basic, it appears that the birth of the basaltic insular volcanoes was at a late date, probably late Diluvium, by which time the magma had become strongly basic.

(2) The insular volcano Ôshima consists mainly of double homates—a somma and a central cone—, and is built up of alternating lava-flows, both superfluent and effluent, and ejecta beds.

The somma has eight parasitic knobs and two phreatic explosion-craters on its flanks, and is truncated at the top with a ring-wall that surrounds a huge oval caldera, about 3 km. in diameter. The wall is not completely closed but has two gaps, a great one on the northeastern and a small one on the southwestern sides.

The central homate, Miharayama,<sup>2)</sup> standing in the caldera, has an active summit crater, 700 m. across. Its volcanic products cover the ground not only within the inside of the encircling wall but have also spread down to the sea shores through the gaps in the wall.

Besides the above, there are along the western half of the

1) 大島 利島 鵜渡根島 三宅島 御蔵島 八丈島

2) 三原山



northern coast, several small demolished igneous bodies now covered by the volcanic materials of the somma.

(3) The rocks constituting the volcano are of several types as already tabulated on p. 67, but they are readily grouped under three main headings,—basaltic bandaite, miharaitite, and basalt.

Basaltic bandaite predominates amongst the lavas of the somma. In it, the phenocrysts of calcic bytownite are scattered through the granular intersertal groundmass consisting of labradorite, augite, magnetite, and a small quantity of glass. Most of the lavas of this type bear a negligible amount of small olivine phenocrysts, though in some this mineral is absent. Hypersthene and augite phenocrysts are either lacking or present only in small quantities.

The type which the writer describes under the new name "miharaitite" constitutes the central cone. It does not differ much from the preceding in its petrographic characters but is characterized by an entire absence of olivine.

Basalt is a variety comparatively rich in phenocrysts of olivine and pyroxene. This constitutes the northwestern demolished igneous bodies, but is very rarely found as the lavas of the somma.

All of these rocks are strongly basic. The chemical analyses made of the first two types of the above three—basaltic bandaite and miharaitite—, which exceed the third in mass, show a remarkable character in that the amount of silica, in spite of its low percentage, is not only enough to form the highest silicates but it is present in excess. This is one of the common characteristics of the most widely spread recent volcanic rocks of Japan, but the rocks of Ôshima are peculiar in their more femic and less quaric natures.

(4) The physiographic history of the volcano since its birth

is summarized as follows :—

The body which now constitutes the somma is the earliest of those so far seen. It was very gradually built up by repeated volcanic actions without any prolonged intervals of quietude. During the development of the somma, but far before its skirt reached the present state of development, extruded lavas comparatively rich in olivine formed small igneous bodies in the north-western part of the present Ôshima, isolated at that time from the main body by the sea. These soon expired and were destroyed by the marine erosion. When the development of the somma was nearly completed, the steep slope running in the direction N.—S. along the east coast of the island was formed by the depression of the ground. Vulcanism displayed its energy not only at the centre of the volcano but also on the flanks of the somma at several spots during various but comparatively later stages in the volcanic history. The products of these flank eruptions are especially abundant in the southeastern part of the island. The depression of the summit of the somma resulted in the formation of a huge caldera whereupon the encircling wall was badly broken in its northeastern quarter. The central homate appeared in the caldera and its products not only filled the inside of the caldera but spread down to the sea shore, especially abundantly in the east through the northeastern gap of the ring-wall. In historic times the volcano continued frequently to display its activity, and eruptions in the following years are on record : 684, 1112, 1416, 1421, 1600–1601, 1612–1613, 1636–1637, 1684–1690, 1777–1778, 1803, 1822, 1846, 1870, 1876–1877, 1912–1914, and 1915.

(5) Turning to the problem of the magma, the original magma is supposed to be basaltic, highly fluidal and with a specific gravity nearly equal to that of the calcic plagioclase crystals. The magma

cooled gradually, separating out the crystals of olivine, plagioclase, and pyroxene, in order as shown in Fig. 40 (p. 117), its temperature becoming at last decisively lower than  $1470^{\circ}\text{C}$ . and probably as low as  $1200^{\circ}$ – $1300^{\circ}\text{C}$ . During the course of the cooling of the magma, the separated crystals were affected by gravitation. Thus, plagioclase, matching the magma closely in density, remained practically suspended in the magma basin; while olivine and pyroxene, being much heavier than the magma, subsided in it toward the bottom as they crystallized out. As a result of the separation and the subsidence of the crystals the originally homogeneous magma became heterogeneous as time passed, the heavy crystals being relatively concentrated at the bottom. All the rocks of Ôshima represent, according to the writer's belief, certain stages after the above-mentioned magmatic temperature had been reached and the subsidence of the heavy crystals had gone on to a fair extent. The rock-type rich in phenocrysts of mafic minerals—basalt—may have been extruded from the lower portion of the magma basin where the mafic minerals were relatively concentrated; while most of the somma lavas in which olivine crystals are either absent or only very sparingly found—basaltic bandaite—are believed to have come from the upper part of the magma basin at the stage when the olivine crystals had half sunk; the central cone lavas which are entirely free from olivine—miharaite—are probably of a still later stage when the subsidence of olivine crystals had progressed still further so that they had no opportunity of entering the lavas as they were extruded.

The effect likely to be brought about by the cooling of the magma was considered and it was concluded that the magma would change from basic to acidie if the cooling proceeded. All the lavas of Ôshima now seen represent only one stage of the above course,

—in other words, the long physiographic history of Ôshima, so far as it can be traced back from structural study, is represented by only one stage in the cooling history of the magma.

(6) Future activity of the volcano Ôshima. The volcanic activity may depend upon many factors, of which the temperature condition of the magma is no doubt most important. Other conditions being equal, a rise of the magmatic temperature would naturally bring about a rise in the volcanic activity, while a fall in temperature would lead to its decay. In the volcano Ôshima, as already stated, the magma appears to have maintained the same temperature throughout all the stages in the physiographic development so far as is traceable. Moreover, the structural feature shows that there has been no prolonged period of quietude in its life history, there being many historical records of violent outbursts, of which the latest one that lasted from 1912 to 1914 is still very fresh in our memory. All in all, the volcano shows no sign of decay in its activity and appears likely to retain for some time the same energy which it has displayed in the past.

Geological Institute, Science College,  
Imperial University of Tôkyô.

# CONTENTS.

	PAGE
<b>I. Introduction</b> .. .. .	1
Geographic Sketch .. .. .	2
Previous Work.. .. .	5
<b>II. Structure and Morphology</b> .. .. .	11
Structural Outline .. .. .	11
Building Materials of the Somma.. .. .	13
Steep Slope along the East Coast.. .. .	16
Vulcanism on the Flanks of the Somma .. .. .	18
The Caldera .. .. .	26
The Central Cone .. .. .	29
Small Demolished Igneou Bsodies along the Western Half of the Northern Coast .. .. .	38
Explanation of the Present Features .. .. .	44
<b>III. Volcanic Activity in Historic Times</b> .. .. .	53
<b>IV. Petrography</b> .. .. .	60
Some Specially Devised Petrographic Methods .. .. .	62
Special Descriptions.. .. .	67
A) Lavas of the Somma .. .. .	67
B) Lavas of the Central Cone .. .. .	79
C) Rocks constituting the Demolished Igneous Bodies along the Western Half of the Northern Coast .. .. .	88
D) Rocks occurring as Dykes .. .. .	94
E) Ejecta .. .. .	96
<b>V. History of the Magma</b> .. .. .	101
Probable High Fluidity of the Magma of Ôshima .. .. .	103
Separation of a Mix-Crystal Series .. .. .	104
Crystallization of the Component Minerals .. .. .	106
Summary on the Cooling History of the Magma .. .. .	116
Development of the Various Rock-Types .. .. .	118
<b>VI. The Geologic Position</b> .. .. .	125
<b>VII. General Summary</b> .. .. .	141





S. Tsuboi:  
Volcano Ôshima, Idzu.

Plate I.

## PLATE I. (Microphotographs)

### Lavas of the Somma.

Basaltic bandaite almost free from phenocrysts of mafic minerals  
(the 1st type of the somma lava). See pp. 67-72.

Fig. 1.—Somma lava with the groundmass of  $\alpha$ -type (pp. 68 & 70). Here the crystallinity and granularity are low, and anhedral magnetite disseminates finely among the other components. The specimen is from the lava delta of Okata on the north coast (Pl. VI. GA 8).  $\times 70$ .

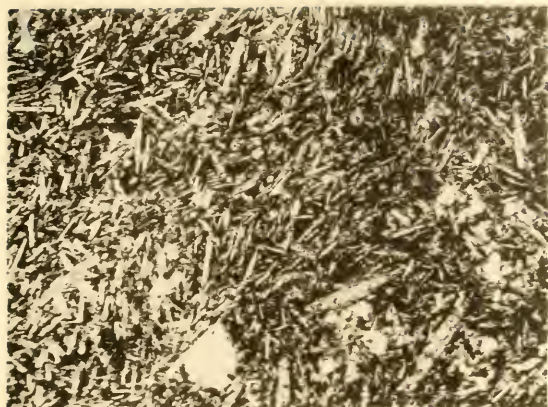
Fig. 2.—Somma lava with the groundmass of the same type as the above, but somewhat higher both in crystallinity and granularity. The specimen was collected from the uppermost lava exposed on the western ring-wall at the point 800 *m.* to S.S.W. of Kagamihata.  $\times 70$ .

Fig. 3.—Somma lava with the groundmass of  $\beta$ -type (pp. 68 & 70). Specimen from the uppermost lava exposed at Tatsunokuchi (Pl. VI. BC 3).  $\times 70$ .

Fig. 4.—Somma lava with the same groundmass texture as the above but with extremely fine granularity (0.008 *mm.* in average diameter of the component minerals). Specimen from the lava exposed at the point, about 1 *km.* to N.N.W. of Harbu, marked  $\otimes$  on Pl. V. 3e.  $\times 70$ .

Fig. 5.—Somma lava with higher crystallinity. The size of magnetite is here as large as 0.08 *mm.* across. Specimen from the uppermost lava on the sea cliff to the east of Sashikiji (Pl. VI. DE 4).  $\times 70$ . See. p. 70.

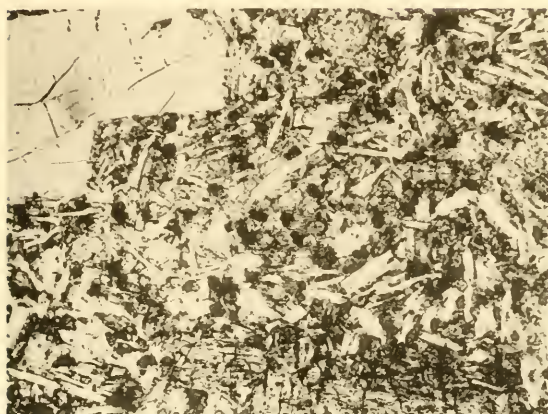
Fig. 6.—Somma lava with similar texture to the above, but with still larger magnetite crystals. The specimen was taken from the sea cliff to the west of Sendzu (Pl. VI. GA 7).  $\times 70$ .



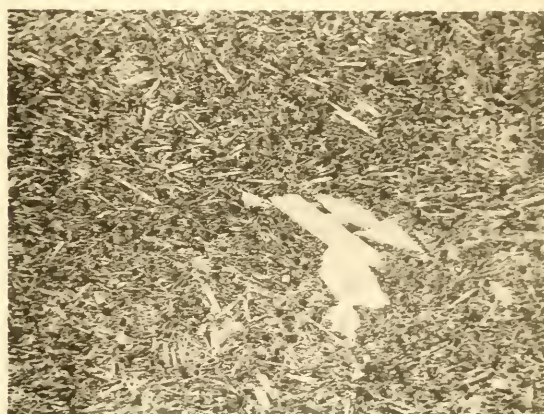
*Fig. 1*



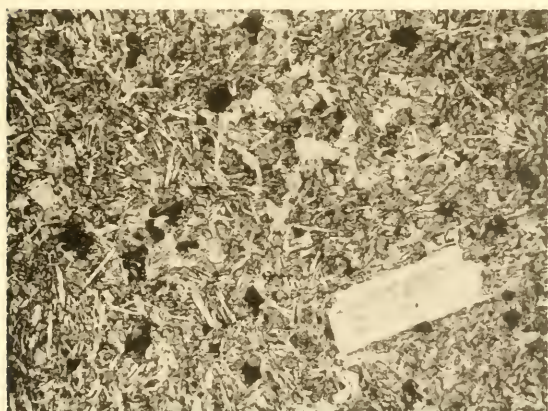
*Fig. 2*



*Fig. 3*



*Fig. 4*



*Fig. 5*



*Fig. 6*



S. Tsuboi ;  
Volcano Ôshima, Idzu.

Plate II.



## PLATE II. (Microphotographs)

- Fig. 1.—Hypersthene-basaltic bandaite (the 2nd type of the somma lava, Pl. VI. BC 2).  $\times 70$ . See p. 73.  $p \dots$  calcic bytownite,  $h \dots$  hypersthene.
- Fig. 2.—Two-pyroxene-basaltic bandaite (the 3rd type of the somma lava), from the lowest lava layer of the three on the sea cliff at Gyôja (Pl. VI. FG 6).  $\times 70$ . See p. 74.  $h \dots$  hypersthene.
- Fig. 3.—The rock of the same type as in Fig. 2, from the uppermost lava layer of the three on the sea cliff at Gyôja (Pl. VI. FG 6).  $\times 70$ . See p. 74.  $p \dots$  calcic bytownite,  $a \dots$  augite.
- Fig. 4.—Hypersthene-bearing augite-olivine-bytownite-basalt (the 4th type of the somma lava, Pl. VI. EF 5).  $\times 70$ . See p. 76.  $p \dots$  calcic bytownite,  $o \dots$  olivine.
- 

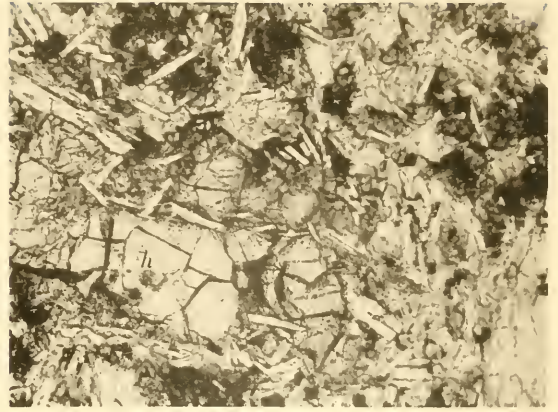
### Lavas of the Central Cone (Miharaite).

- Fig. 5.—An older lava collected from the lowest exposed layer on the eastern crater-wall.  $\times 70$ . See p. 79.  $p \dots$  calcic bytownite.
- Fig. 6.—Lava of 1778 (An-ei era), collected from the lava field on the northern flank of the central cone.  $\times 70$ . See p. 80.  $p \dots$  calcic bytownite,  $h \dots$  hypersthene,  $a \dots$  augite.

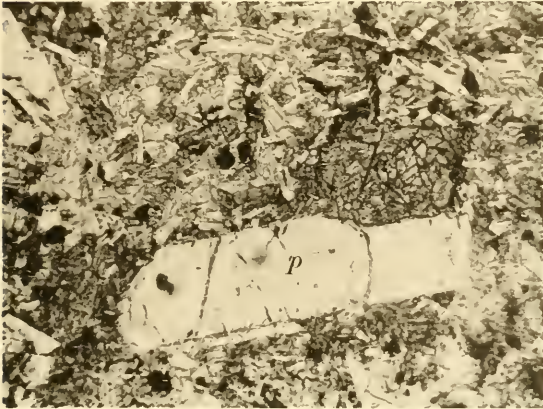




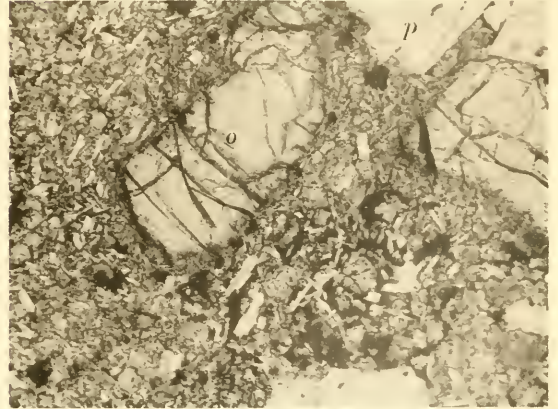
*Fig. 1*



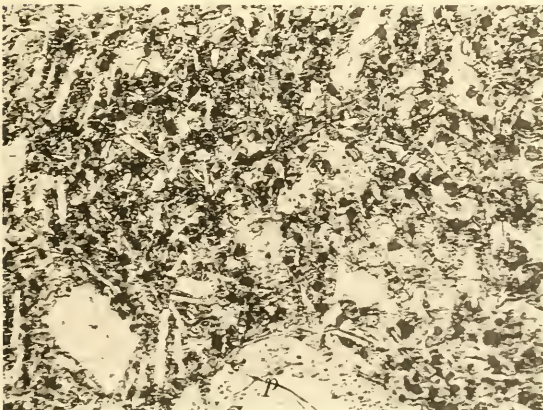
*Fig. 2*



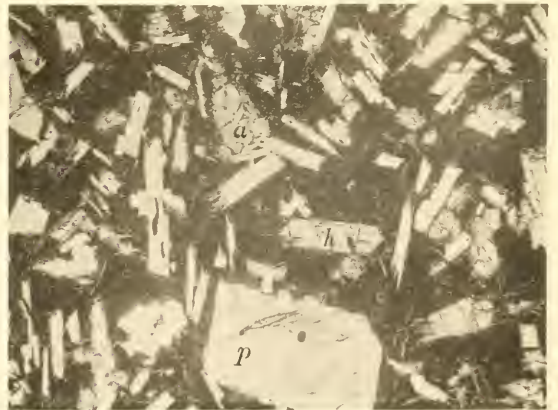
*Fig. 3*



*Fig. 4*



*Fig. 5*



*Fig. 6*



S. Tsuboi:

Volcano Ôshima, Idzu.

Plate III.

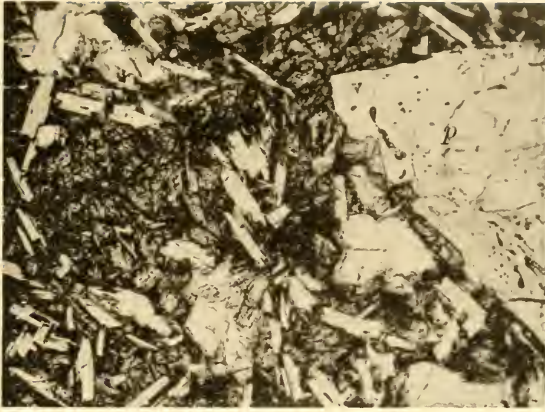
### PLATE III. (Microphotographs)

- Fig. 1.—The holocrystalline part of the lava of April 1912.  $\times 70$ . See p. 81. *p*....calcic bytownite, *a*....augite.
- Fig. 2.—The hyalocrystalline part of the same, with no visible magnetite crystals.  $\times 70$ . See p. 81. *p*....calcic bytownite, *r*....rhombic lamella (p. 82), *g*....brown glass.
- Fig. 3.—The lava of September-October 1912, showing the groundmass of intermediate crystallinity.  $\times 135$ . See p. 81. *p*....calcic bytownite, *m*....dendritic skeletal crystal of magnetite.
- Fig. 4.—The lava of May 1914, now making the crater-floor.  $\times 40$ . See p. 81. *p*....calcic bytownite, *c.h*....clino-hypersthene.
- 

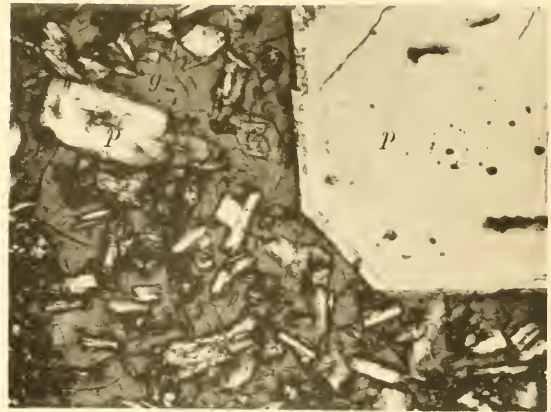
### Rocks of the Northwestern Demolished Igneous Bodies.

- Fig. 5.—Two-pyroxene-olivine-anorthite-basalt, constituting the igneous body of Chigasaki (Pl. VI. GA 14).  $\times 70$ . See p. 89. *p*....anorthite, *o*....olivine.
- Fig. 6.—Olivine-bytownite-basalt (*a*), constituting the igneous body of Kazahaya (Pl. VI. GA 13).  $\times 70$ . See p. 92. *o*....olivine.

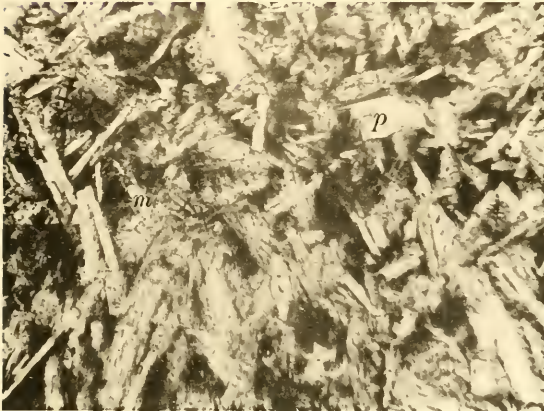




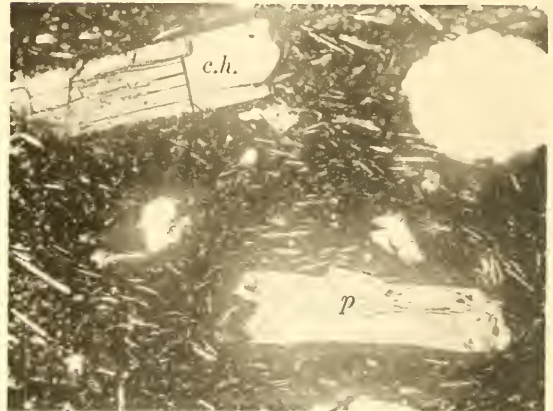
*Fig. 1*



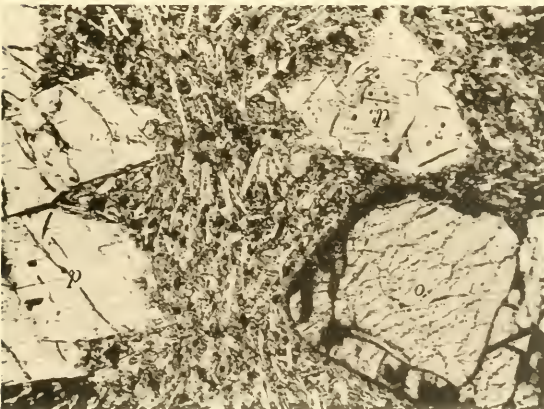
*Fig. 2*



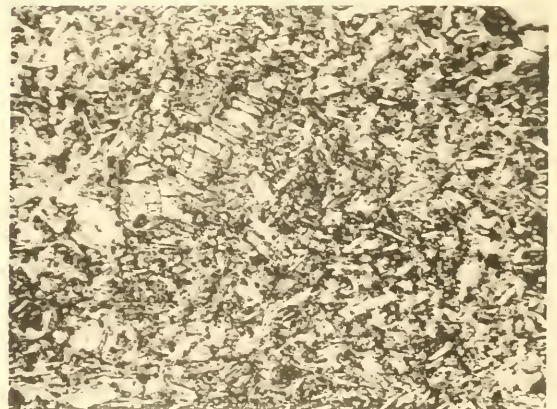
*Fig. 3*



*Fig. 4*



*Fig. 5*



*Fig. 6*





S. Tsuboi:  
Volcano Ôshima, Idzu.

Plate IV.

## PLATE IV. (Microphotographs)

Fig. 1.—Olivine-bytownite-dolerite, constituting the igneous body (Pl. VI. GA 11) to the east of Kazahaya.  $\times 70$ . See p. 93. *p* . . calcic bytownite, *a* . . . . augite, *o* . . . . olivine.

Fig. 2.—Olivine-bytownite-basalt ( $\beta$ ), constituting the igneous body (Pl. VI. GA 9) to the west of Okata.  $\times 70$ . See p. 94. *p* . . . . calcic bytownite, *o* . . . . olivine with brown iron oxide along the margin.

---

### Rocks occurring as Dykes.

Fig. 3.—Olivineless basaltic bandaite (*a*), the rock of the dykes exposed on the cliff opposite to Fudeshima.  $\times 70$ . See p. 95. *p* . . . . calcic bytownite, *a* . . . . augite.

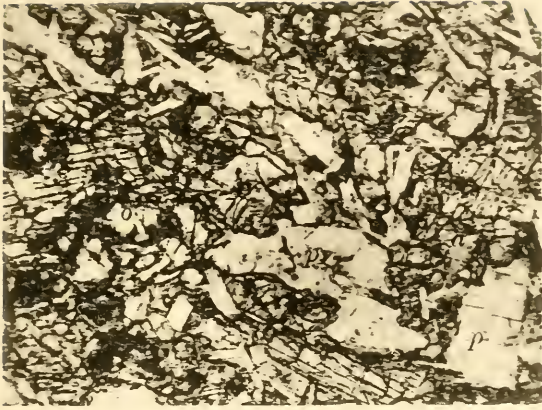
Fig. 4.—Olivineless basaltic bandaite ( $\beta$ ), the rock of the southernmost dyke of the three on the western ring-wall of the somma.  $\times 135$ . See p. 95. *p* . . . . calcic bytownite, *a* . . . . augite.

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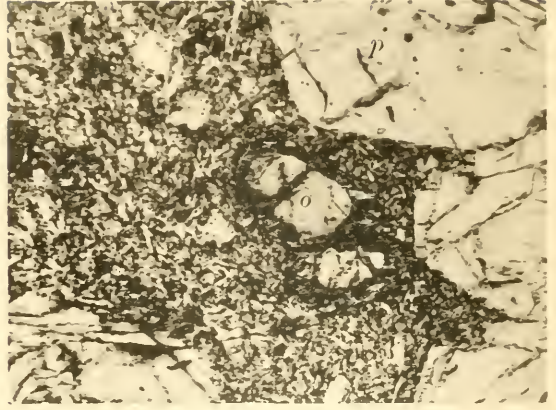
### Phanerocrystalline Ejecta.

Fig. 5.—Micro-allivalite.  $\times 20$ . See p. 98. *p* . . . . anorthite, *o* . . . . olivine.

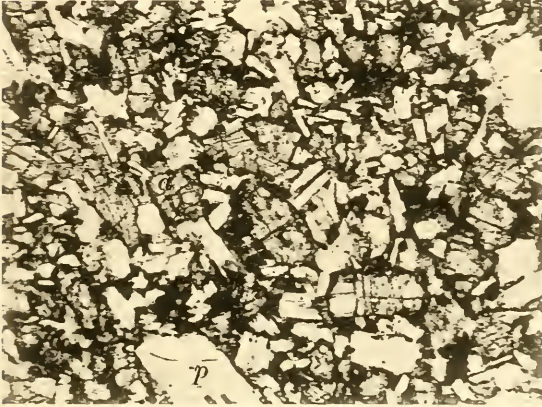
Fig. 6.—Augite-micro-diorite.  $\times 30$ . See p. 99. *p* . . . . andesine-labradorite, *a* . . . . unusual augite, *s* . . . . salic interstitial matter.



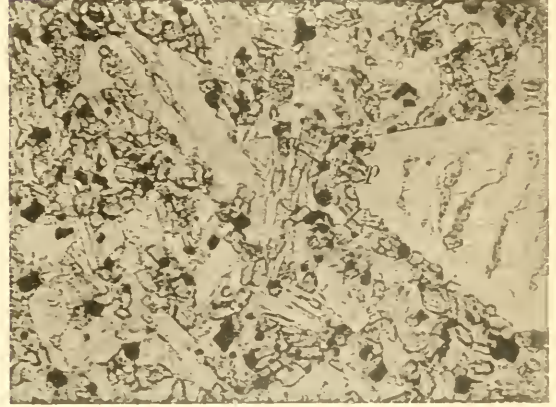
*Fig. 1*



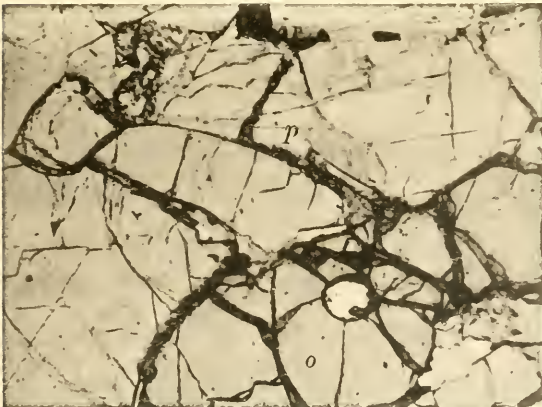
*Fig. 2*



*Fig. 3*



*Fig. 4*



*Fig. 5*



*Fig. 6*



S. Tsuboi:  
Volcano Ôshima, Idzu.

Plate V.

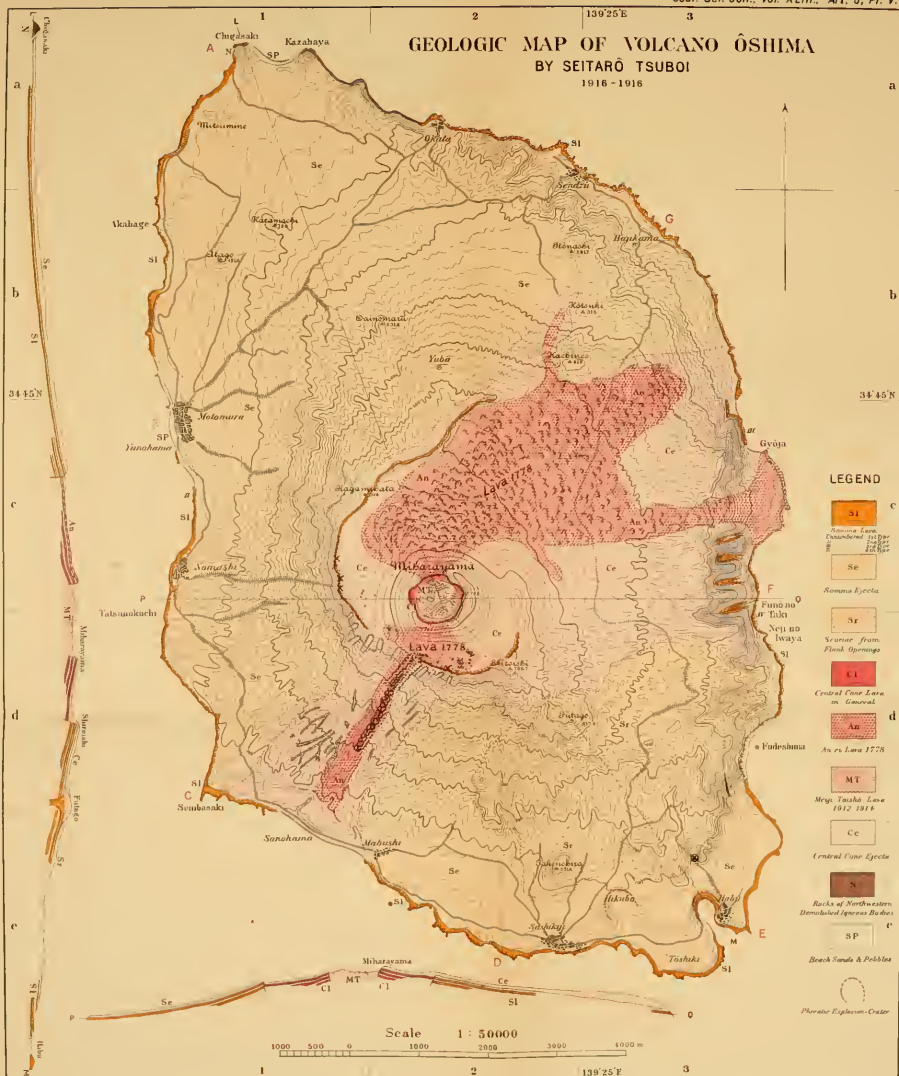
## **PLATE V.**

### Geologic Map of Volcano Ôshima.

The geologic map of this plate is virtually divided by vertical and transverse lines into squares, which are referred to by the numerals and letters on the margin. Reference indices in the text, following locality names, indicate the square in which those names are to be found. Red reference letters, A B C . . . G, around the coast, correspond with those in Pl. VI.



# GEOLOGIC MAP OF VOLCANO ÔSHIMA BY SEITARÔ TSUBOI 1916-1918





S. Tsuboi:  
Volcano Ôshima, Idzu.

Plate VI.

## PLATE VI.

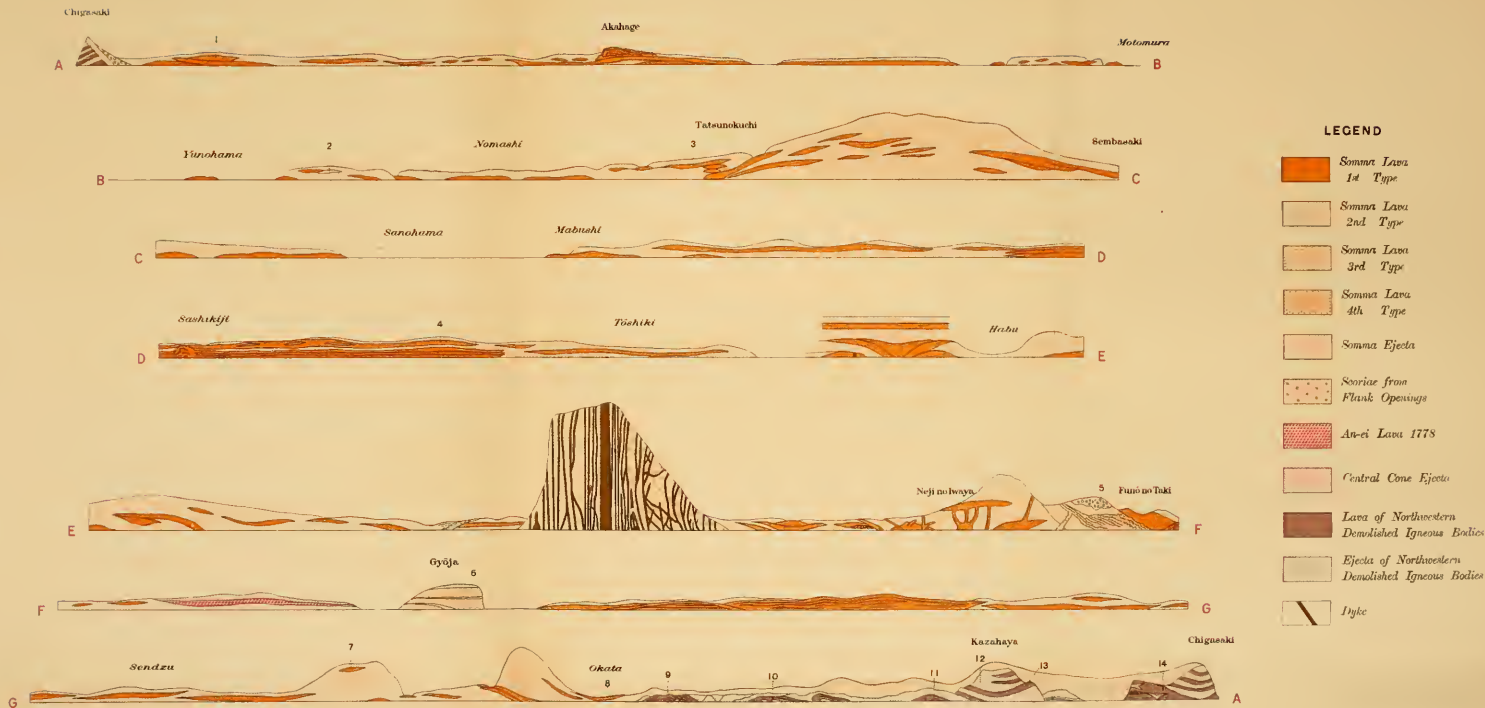
Diagrammatic Sketch of the Exposures on the Coastal Cliff.

Red reference letters, A B C . . . G, correspond with those in the geologic map of Pl. V. Arabic figures, 1 2 3 . . . 14, refer to the text and explanations of plates as follows:—

- 1 . . . P. 69.
- 2 . . . Pp. 14, 73 ; Expl. of Pl. II. Fig. 1.
- 3 . . . P. 7 ; Expl. of Pl. I. Fig. 3.
- 4 . . . Pp. 70, 120 ; Expl. of Pl. I. Fig. 5.
- 5 . . Pp. 14, 77 ; Expl. of Pl. II. Fig. 4.
- 6 . . . Pp. 14, 75 ; Expl. of Pl. II. Figs. 2-3.
- 7 . . Expl. of Pl. I. Fig. 6.
- 8 . . Expl. of Pl. I. Fig. 1.
- 9 . . . Pp. 41, 94 ; Expl. of Pl. IV. Fig. 2.
- 10 . . . Pp. 41, 93.
- 11 . . . Pp. 41, 93 ; Expl. of Pl. IV. Fig. 1.
- 12 . . . Pp. 98, 121.
- 13 . . . P. 92 ; Expl. of Pl. III. Fig. 6.
- 14 . . . P. 89 ; Expl. of Pl. III. Fig. 5.

# DIAGRAMMATIC SKETCH OF EXPOSURES ON THE COASTAL CLIFF

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Horizontal Scale 1/20000 Vertical Scale 1/5000





## Cytologische Studien an Einigen Kompositen.

Von

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Mit 4 Tafeln und 15 Textfiguren.

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### I. Einleitung.

In der letzten Zeit sind die Kompositen schon vielfach von verschiedenen Forschern zum Gegenstande der cytologischen Untersuchungen gemacht worden. Bekanntlich haben diese Untersuchungen viele sehr interessante Ergebnisse vor uns geführt; nämlich fanden Juel (1916), Murbeck (1901), Rosenberg (1907) und Holmgren (1916) die parthenogenetische Embryobildung bei *Antennaria*, *Taraxacum*, *Hieracium*, *Chondrilla* und *Eupatorium*. Die Schwankung der Chromosomenzahl unter den nahe verwandten Arten beschrieben Rosenberg (1907), Ishikawa (1916) u. a. bei den verschiedenen Gattungen dieser Familie. Die niedrigste Chromosomenzahl unter den Phanerogamen entdeckte Rosenberg (1909) bei *Crepis virens*. Ferner schrieb Palm (1914, 1915) die interessante Embryosackentwicklung bei *Pyrethrum* (*Chrysanthemum*), *Tanacetum* u. a.

Seit einigen Jahren habe ich mich auch auf den Vorschlag von Herrn Professor Dr. K. Fujii mit den cytologischen Untersuchungen

bei einigen Arten von *Chrysanthemum* und *Erigeron* beschäftigt. Vorläufige Mitteilung von dieser Untersuchung wurde schon in Botanical Magazine, Tokio, vols. 28 u. 29 (1914–1915) gegeben.

Als Fixierungsmittel benutzte ich Flemmings Chrom-Eisessig mit oder ohne Osmiumsäure, Carnoys Alcohol-Chloroform-Eisessig, Bouins Pikrin-Eisessig-Formalin u. a. Aber wie es sich alsbald zeigte, pflegte die erste Fixierungsflüssigkeit ein besseres Resultat als die anderen zu ergeben, so dass ich mich in den späteren Studien nur an dieses Fixierungsmittel hielte. Bei der Benutzung dieser Lösung tauchte ich aber zuerst das Material 15–30 Minuten in Carnoys Fixierungsmittel, spülte dann in 95% Alcohol und legte es endlich in Flemmings Flüssigkeit ein. Diese Methode lieferte für die meisten Fälle ein ganz befriedigendes Resultat. Zum Färben habe ich Heidenhains Eisenhämatoxylin, Flemmings Safranin-Gentianaviolett-Orange und Safranin-Lichtgrün benutzt. Die letztgenannte Methode ergab vortreffliche Verdienste bei den Fällen, wo die Zellwandfärbung dringend erforderlich war.

Die Untersuchung wurde im botanischen Institut der wissenschaftlichen Fakultät der kaiserlichen Universität zu Tokio unter der Leitung von Herrn Professor Dr. K. Fujii im Herbst 1913 angefangen und im Sommer 1916 abgeschlossen. Ich möchte hier die Gelegenheit benutzen, meinem hoch verehrten Lehrer für seine allseitige Unterstützung und Anregung meinen herzlichsten Dank auszusprechen. Auch den Herren, die mir das Material zu dieser Untersuchung freundlich zur Verfügung gestellt haben, bin ich zu vielem Danke verpflichtet.

## II. *Chrysanthemum*.

### 1. DIE CHROMOSOMENZAHLEN.

*Chrysanthemum* ist eine grosse Gattung unter den Kompositen.

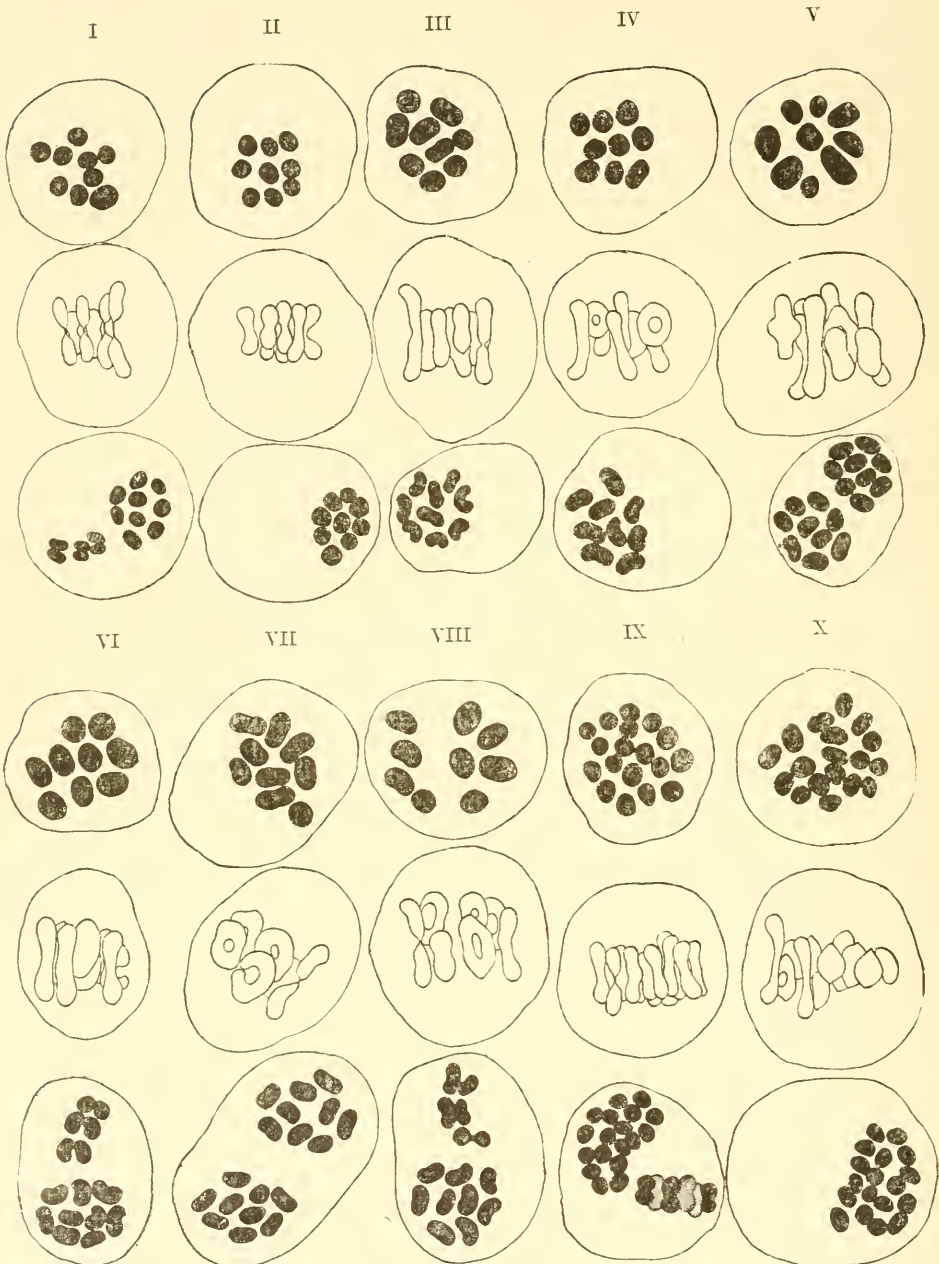
Es umfasst etwa 200 Arten. In Japan wachsen ihrer 11 Arten wild. In der vorliegenden Arbeit wurden nicht nur diese einheimischen Arten, sondern auch die Pflanzen aus fremden Ländern zur Untersuchung gezogen.

Die Chromosomenzählung geschah meistens in den Pollenmutterzellen, da diese Zellen natürlich für solche Untersuchung besonders geeignet sind. Aber in einigen Fällen gelang es mir nicht, das Material von den Pollenmutterzellen zu bekommen. Da verwandte ich die Wurzelspitzen der betreffenden Pflanzen als Material für die Feststellung der Chromosomenzahl.

Es ist eine bemerkenswerte Tatsache, dass die Haploidchromosomenzahl der vielen Arten von *Chrysanthemum* und von dessen verwandten Gattungen übereinstimmend 9 beträgt. Schon durch die Untersuchungen von Rosenberg (1905), Lundegårdh (1909) und Beer (1912) ist es gezeigt worden, dass *Tanacetum vulgare*, *Matricaria Chamomilla* und *Anthemis tinctoria* sämtlich diese Chromosomenzahl aufweisen. Bekanntlich stehen alle diese Pflanzen in engerer Verwandtschaft mit *Chrysanthemum*.

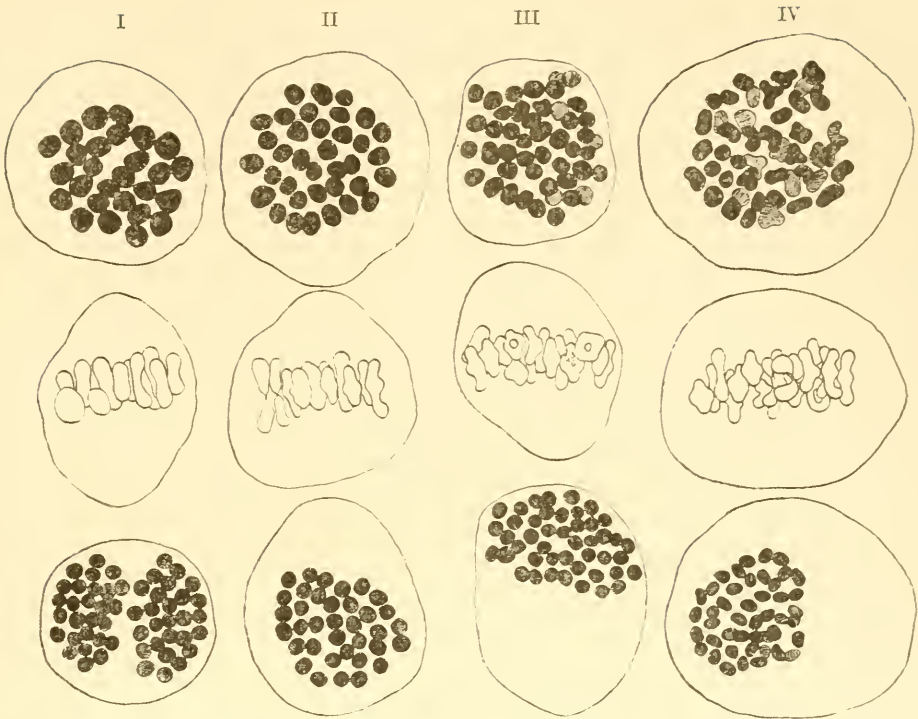
Eine Spezies von *Matricaria*, namentlich *M. ambigua* Ledeb. wächst in nördlichem Japan wild. Diese Pflanze wird aber in Tokio hier und da gezüchtet. Die Haploidchromosomenzahl von dieser Pflanze beträgt auch neun.

Unter den *Chrysanthemum*-Arten konnte ich weiter auch dieselbe Chromosomenzahl an 10 Arten feststellen, d. i. *Ch. japonicum*, Mak. *Ch. lavandulifolium*, Mak. *Ch. cinerariifolium*, Brocc. *Ch. roseum*, Webb et Mohr. *Ch. nipponicum*, Franch. *Ch. segetum*, L. *Ch. coronarium*, L. *Ch. carinatum*, Schoub. *Ch. lineale*, Matsum. *Ch. myconis*, L. Die Grösse und die Gestalt der Chromosomen bei der meiotischen Teilung sind aber unter den Arten nicht übereinstimmend. Dieser Zustand ist in Textfig. 1. klar vergegenwärtigt



Textfig. 1. Hetero- und homöotypische Kernteilungen der Chrysanthemen. I. *Ch. japonicum*. II. *Ch. lavandulifolium*. III. *Ch. cinerariifolium*. IV. *Ch. roseum*. V. *Ch. nipponicum*. VI. *Ch. segetum*. VII. *Ch. coronarium*. VIII. *Ch. carinatum*. IX. *Ch. indicum*. X. *Ch. Leucanthemum*. ( $\times 1600$ )





Textfig. 2. Hetero- und homöotypische Kernteilung der Chrysanthemen. I. *Ch. morifolium*. II. *Ch. Decaisneanum*. III. *Ch. marginatum*. IV. *Ch. arcticum*. ( $\times 1600$ )

worden. Diese Figur weist die hetero- und homöotypischen Kernteilungen auf. Die oberste Reihe zeigt die Polansicht der heterotypischen Kernteilung, die nächste die Seitenansicht derselben und die unterste die Pol- und Seitenansicht der homöotypischen Kernteilung.

Es giebt aber unter den Chrysanthemen die andere Chromosomenzahl aufweisenden Arten. Nämlich weisen an der Haplochromosomenzahl auf: *Ch. indicum*, L. und *Ch. Leucanthemum*, L. 18 (Textfig. 1., IX, X), *Ch. hakusanense*, Mak. und *Ch. morifolium*, Ram. 27 (Textfig. 2, I), *Ch. Decaisneanum*, Matsum. 36 (Textfig. 2, II), *Ch. marginatum*, Miq. und *Ch. arcticum* L. 45 (Textfig. 2, III. IV.). Diese Chromosomenzahlen bilden sich aber merkwürdigerweise eine gesetzmässige Reihe der Multiplen von 9.

Diesähnliche Zahlenverhältnisse der Chromosomen wurden, wenn auch nicht so ausgeprägt wie bei diesem Falle, schon mehrfach sowohl bei Pflanzen als auch bei Tieren gefunden. Einige davon sind unten hervorgehoben.

Tischler (1900) schreibt einen solchen Fall bei drei Rassen von *Musa sapientum*. Nämlich hat „Dole“ 8, „Radjah Siam“ 16, „Kladi“ 24 als die Haploidchromosomenzahlen. Ähnliches finden wir auch bei den Chromosomenzahlen von *Viola*-Arten. Nach Miyaji (1913) hat als reduzierte Zahlen *V. glabella* 6, *V. nipponica* 10, *V. Okuboi* und *V. phalerocarpa* 12, *V. japonica* 24, *V. Patrini* 36 (?).

Von Interesse ist es ferner, dass nach den neueren Erfahrungen die Verdoppelung der Chromosomenzahl in Zusammenhang mit Bastardierung wenigstens öfters bei *Primula* stattzufinden scheint (Digby, 1912; Gregory, 1914).

Das Auftreten von Tri- und Tetraploidmutant in *Oenothera*-kulturen ist heute schon allzubekannte Tatsache (Lutz, 1907; Lutz, 1912).

Anzuführen wäre in diesem Zusammenhange noch, dass die vielen parthenogenetischen Gewächse ja auch bekanntlich im Verhältnisse zu den normalgeschlechtlichen Arten derselben Gattung oft exakt doppelt so viele Chromosomen bei den Kernteilungen aufweisen (Juel, 1900; Overton, 1904; Strasburger, 1905).

Unter diesen Umständen sind die Fragen sehr bedeutungsvoll, wodurch diese Verdoppelung der Chromosomenzahl in jedem einzelnen Falle veranlasst werden und ferner was für ein Prozess sich dabei geltend machen soll. Doch wissen wir auf diese Frage noch nichts mit einiger Bestimmtheit zu antworten.

Meiner Meinung nach könnte die folgende Annahme unter anderen (Strasburger, 1910; Nemec, 1910 u. 1912; Gates, 1915)



auch als die wahrscheinlichste betrachtet werden: Die zu Grunde liegende Ursache für die Chromosomenzahlverdoppelung sei die Steigerung der Vegetationstätigkeit der Eizelle. Durch diese zu Grunde liegende Ursache veranlasst, werde die Chromosomenzahlverdoppelung in verschiedenen Orten, und auf verschiedene Weisen ausgeführt. In einem Falle könnte die Verdoppelung durch die zweimaligen Längsspaltungen der Chromosomen bei der ersten Kernteilung der Eizelle herbeigeführt sein. Tatsächlich wurden die zweimaligen Längsspaltungen der Chromosomen von Strasburger (1908) im Antipodalende des Embryosackes von *Lilium* beobachtet. Das Antipodalende ist nach ihm bei dieser Pflanze auch wie bei den anderen die an Nährstoff reichlichste Region des Embryosackes. Nun werden wir auf einen anderen Fall übergehen.

Die wiederholten Untersuchungen lehren uns, dass die Konjugationstätigkeit der einzelligen Organismen durch die Verbesserung des Ernährungszustandes eine nennenswerte Retardierung erfährt. In analogischer Weise sollte die Paarungskraft zwischen den homologen Chromosomen bei der Steigerung der Vegetationstätigkeit geschwächt werden. Und dies könnte sich natürlich leicht zur Unterlassung der heterotypischen Kernteilung bei der Sporenbildung von dieser Pflanze führen. Dann mit den normalen Keimzellen vermenget finden wir die Zellen, welche doppelte Chromosomenzahl aufzuweisen haben. Durch die Befruchtung dieser Zellen mit den normalen würden die Pflanzen mit den tri- bzw. hexaploiden Chromosomen auftreten.

Diese Hypothese deutet also darauf hin, dass die Chromosomenverdoppelung durch einzig und alleinige Ursache ausgelöst werden, doch diese Erscheinung je nach dem Falle bald bei der ersten Kernteilung der befruchteten Eizelle, bald bei der nächsten heterotypischen Kernteilung der Embryosack- oder Pollenmutter-

zelle zum Vorschein kommen soll.

Nun werden die sonst sehr schwierigen Probleme durch diese Hypothese leicht erklärt. Zum Beispiele wird eine spontane Steigerung der Vegetationstätigkeit bekanntlich öfters durch die Bastardierung veranlasst. Es ist also kein Wunder, dass die Chromosomenverdoppelung öfters bei den Bastardierungen stattzufinden pflegt.

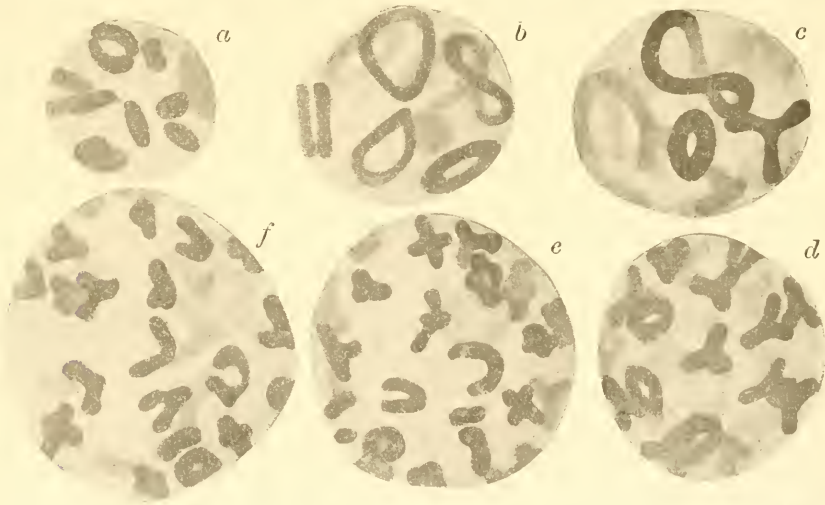
Ohne besondere Schwierigkeit können wir auch die Chromosomenzahlverdoppelung bei den parthenogenetischen Pflanzen erklären. Wie oben gesagt, bringt die Steigerung von Vegetationstätigkeit eine gewisse Retardierung der geschlechtstätigkeit hervor. Also sollte die Pflanze, welche durch die Steigerung der Vegetationstätigkeit die Chromosomenzahlverdoppelung beim ersten Vorgang der Entwicklung ausgeführt hat, auch von Anfang an die Fähigkeit haben, die Samen in parthenogenetischer Weise zu produzieren. Dann kann in dieser Hinsicht die von Strasburger geäußerte Vermutung, dass die Verdoppelung der Chromosomenzahl die Parthenogenesis veranlassen könne, mit unserer Annahme nicht übereinstimmen.

## 2. KERNGRÖSSE.

Wie schon durch die Forschungen von mehreren Cytologen wiederholt gezeigt, pflegt die Grösse des Kerns mit dessen Chromosom in einem intimen Verhältnisse zu stehen. Meine Beobachtung in bezug auf diese Erscheinung bei *Chrysanthemum* wird unten kurz mitgeteilt werden. Bei solcher Untersuchung ist es nötig, ein ganz passendes Vergleichsstadium zu bestimmen. Für dieselbe wählten Gates (1909) und Tischler (1910) seinerzeit die Synapsis der Pollenmutterzellkerne. Aber es scheint mir die Diakinese derselben Kerne mehr günstiges Stadium für die Vergleichung der

Kerngrösse zu sein, weil die Synapsis, wie schon wohl bekannt, ein etwas lang dauerndes Stadium ist und während dieses Stadiums die Grösse des Kerns beträchtlich vergrössert wird. Also wurden die weiter unten angegebenen Messungen der Kerngrösse sämtlich an den Kernen im Diakinesenstadium vorgenommen.

Da die Kerngrösse nicht mit der Chromosomenzahl, sondern mit dem Gesamtvolum der Chromosomen in irgend einem Verhältnis zu stehen pflegt, weisen die Kerne, welche mit Chromosomen von derselben Zahl ausgestattet sind, auch oft einen entscheidenden Unterschied der Grösse auf. Textfig. 3, *a* und *b* zeigen die Diakinesenkerne von *Ch. lavandulaefolium* und *Ch. nipponicum*.



Textfig. 3. Diakinesenkerne von verschiedenen Chrysanthemen. *a.* *Ch. lavandulaefolium*. *b.* *Ch. nipponicum*. *c.* *Ch. Leucanthemum*. *d.* *Ch. morifolium*. *e.* *Ch. Decaisneanum*. *f.* *Ch. arcticum*. ( $\times 2700$ )

Diese beiden Arten haben, wie schon erwähnt, dieselbe Chromosomenzahl. Aber wegen des ausgezeichneten Unterschiedes des Gesamtvolums der Chromosomen einen beträchtlichen Unterschied. Die zahlreichere Chromosomenzahl aufweisenden Kerne von anderen *Chrysanthemum*-Arten sind in Textfig. 3, *c-f* zur Abbildung gebracht.

Die Volumen dieser Kerne vergrössern sich Hand in Hand mit der Zunahme der Chromosomenzahl, weil hier die Zunahme der Chromosomenzahl auch von der Zunahme des Gesamtvolumens der Chromosomen begleitet ist. Aber von Anfang an steht es fest, dass ein regelmässiges numerisches Verhältnis unter den Kernvolumina dieser verschiedenen *Chrysanthemum*-Arten schwer zu entdecken ist, da die die niedrigste Chromosomenzahl aufweisenden *Chrysanthemum*-Arten, aus welchen die verschiedenen höhere Chromosomenzahl aufzuweisenden Arten abstammen können, bereits die Verschiedenheit der Kerngrösse aufweisen. Eine Angabe in bezug auf die Kerngrösse der zu meiner Untersuchung gezogenen *Chrysanthemum*-Arten wird unten durch eine Tabelle veranschaulicht. Die Durchmesser der Kerne sind hier in Teilstriichen des Ocularmikrometers angegeben. Der Abstand zwischen zwei Teilstriichen entspricht  $8/5 \mu$ .

Pflanzen-Name	Chromo- somenzahl	Kern- Durchmesser	Radius <sup>3</sup>
<i>Ch. lavandulæfolium</i>	9	5.1	17.6
<i>Ch. roseum</i>	„	5.4	19.7
<i>Ch. japonicum</i>	„	6.0	29.0
<i>Ch. nipponicum</i>	„	6.0	27.0
<i>Ch. coronarium</i>	„	7.0	43.1
<i>Ch. carinatum</i>	„	7.0	43.1
<i>Ch. Leucanthemum</i>	18	7.3	50.7
<i>Ch. morifolium</i>	21	7.8	57.3
<i>Ch. Decaisneanum</i>	36	8.8	85.4
<i>Ch. arcticum</i>	45	9.9	125.0

### 3. EMBRYOSACKMUTTERZELLE.

Während meiner Untersuchung von Pollenmutterzellen bei verschiedenen *Chrysanthemum*-Arten fiel es mir auf, dass einige Arten von ihnen durch die Mehrzelligkeit der Embryosackmutterzelle gekennzeichnet sind. Diesähnliches steht aber bei Kompositen nicht



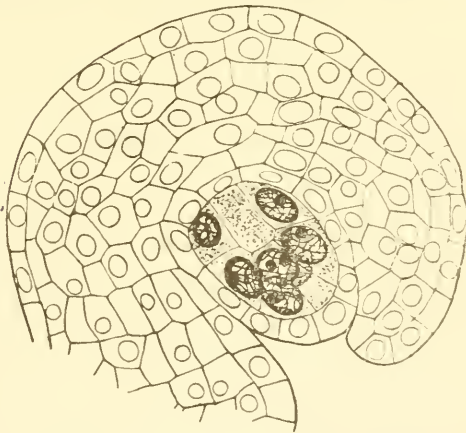
vereinzelt. Und zwar sind beim *Chrysanthemum* schon drei Beispiele davon bekannt: bei *Ch. Leucanthemum* (Jönsson, 1880) *Ch. balsaminatum* (Ward, 1880) und *Ch. corymbosum* (Palm, 1914). Also scheint die Mehrzelligkeit der Embryosackmutterzelle eine grosse Verbreitung in dieser Gattung zu finden. Doch kann sie aber nicht als eine gemeinsame Eigenschaft von dieser Gattung betrachtet werden. Die unten stehende Tabelle zeigt nun deutlich, wie verschiedenen der Grad der Mehrzelligkeit der Embryosackmutterzelle bei *Chrysanthemum* sein kann.

Pflanzenname	Zahl d. E.M.Z. in dem. Nucellus	Durchschnitt derselben
<i>Ch. roseum</i>	10—5	7.3
<i>Ch. coronarium</i>	6—4	5.2
<i>Ch. carinatum</i>	7—3	5.1
<i>Ch. Leucanthemum</i>	4—2	3.2
<i>Ch. frutescens</i>	3—2	2.6
<i>Ch. arcticum</i>	2—1	1.1
<i>Ch. nipponicum</i>	1	1.0
<i>Ch. Deccaisneanum</i>	1	1.0

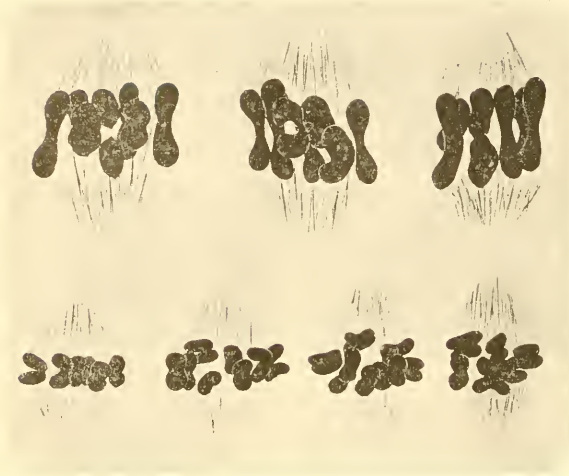
Wie die Tabelle zeigt, tritt die Mehrzelligkeit der Embryosackmutterzelle bei den im Garten kultivierten Arten besonders ausge-

prägt hervor. Da kann man annehmen, dass eine Beziehung zwischen diesen beiden vorhanden sei.

Die nebenstehende Figur 4 zeigt einen Längsschnitt der Samenanlage von *Chrysanthemum roseum*. Die im Centrum des Nucellus



Textfig. 4. Samenanlage von *Ch. roseum*.  
( $\times 500$ )



Textfig. 5. Hetero- und homöotypische Kernspindeln aus ein und demselben Nucellus von *Ch. roseum*. ( $\times 2000$ )

liegenden grosskernigen Zellen sind sämtlich Embryosackmutterzellen. Noch merkwürdiger ist es, dass bei dieser Pflanze bei den meiotischen Mitosen keine Zellwandbildung stattfindet. Diesähnliche Erscheinung ist von Palm neuerlich bei einigen Kompositen beschrieben worden (Palm, 1914). Und

zwar entwickelt nach ihm *Chrysanthemum partheniifolium* den 16 kernigen Embryosack durch die zweimaligen Teilungen der in dieser Weise entstehenden vier Kerne. Unter diesen Umständen bietet die Untersuchung der weiteren Schritte in der Embryosackentwicklung von *Chrysanthemum roseum* ein grosses Interesse. Doch konnten wir leider bei diesem Falle, wegen des wirren Durcheinanders von mehreren Embryosäcken, keine weiteren Embryosackentwicklungen verfolgen.

#### 4. PROPHASE DER HETEROTYPISCHEN KERNTHEILUNG.

Hand in Hand mit den Fortschritten der genetischen Untersuchungen fühlen wir jetzt von neuem eine dringende Notwendigkeit der genaueren Kenntnisse über die einzelnen Punkte der Reduktionsteilung. Unter den Cytologen doch besteht es heutigen Tages noch eine gewisse Meinungsverschiedenheit in bezug auf die einigen Punkte, wovon der wichtigste die Entstehungsweise der Gemini bei der Prophase der heterotypischen Prophase ist. Vor



allem behaupten einerseits Farmer und Moore die Faltungstheorie, während andererseits Strasburger, Gregoire u. a. die Spaltungstheorie aufzustellen versuchen.

Die Pollenmutterzellen von einigen *Chrysanthemum*-Arten führen uns bedeutend klare Bilder von Reduktionsteilung vor. Sie scheinen mir übrigens dem von den bisher beschriebenen etwas abweichenden Schema zu gehören und ein Licht auf dieses schwierige Problem zu werfen.

Als das Hauptuntersuchungsmaterial wählte ich *Chrysanthemum coronarium*. Die zwölf Figuren von Taf. 1 stellen die aufeinanderfolgenden Stadien der heterotypischen Prophase in den Pollenmutterzellen von diesem Gewächse dar. Auf die Veröffentlichung der übrigen Figuren der hetero- und der homöotypischen Kernteilung verzichte ich bei diesem Falle sämtlich, da sie nichts Besonderes darzubieten scheinen. Die im folgenden gegebenen Beschreibungen beziehen sich auch ausschliesslich auf die Vorgänge in der Prophase der heterotypischen Kernteilung.

Fig. 1 zeigt einen Kern, der sich jetzt im Ruhestadium befindet. Wie bei den meisten Monocotylen liegt eine grosse Anzahl von Chromatinkörnchen gedrängt vor; sie stimmen in ihrer Grösse nicht überein. In solchem Kerne können wir keine Fadenstruktur erblicken. Es giebt ein, zwei oder noch mehr Kernkörperchen im Kernraum. Inzwischen scheint ihre gegenseitige Verschmelzung beim ersten Eintritt des Teilungsvorgangs stattzufinden: in den in Prophase der heterotypischen Mitose befindlichen Kernen finden wir durchweg, abgesehen von den seltenen Fällen, nur einzigen Nucleolus vor. Dabei jedoch erfahren die Chromatinkörnchen eine Retardierung an ihrer Grösse, vielleicht durch die Zergliederung in die kleineren Teilchen und werden an den unterdessen im Kernraum scharf aufgetretenen Kernfäden gleichmässig verteilt. Die Fäden

sind zunächst sehr zart; ihre Einzelheiten sind aber nur bei den besonders begünstigten Präparaten deutlich zu beobachten. Fig. 2 zeigt einen Kern in solcher Entwicklungsstufe, wo sich die Innenstruktur mit besonderer Klarheit wahrnehmen lässt. Die in dem Kernraum herum durchlaufenden Fäden bieten uns eine Parallelanordnung in einer ausgeprägten Weise. Bekanntlich wurde dieselbe Erscheinung schon wiederholt entdeckt und von einer Reihe Autoren als die parallele Anordnung von den homologen d.i. väterlichen und mütterlichen Kernfäden gedacht. Es scheint mir auch hier keine andere Auffassung zulässig zu sein.

Inzwischen geht der Kern auf Synapsisstadium über. Die aufeinanderfolgenden Stufen dieses etwas lange andauernden Stadiums sind in Fig. 3–6 abgebildet. Der Fadenparallelismus ist diese Stufen hindurch sehr deutlich wahrnehmbar. Im Einklang mit dem Fortschreiten des Teilungsvorgangs nimmt der Faden in seiner Tinktionsfähigkeit und Dickigkeit mehr und mehr zu. Und schliesslich am Ende dieses Stadiums kommt schon merkwürdigerweise die frühzeitige Längsspaltung des Kernfadens vor.

Die meisten Anhänger der Faltungstheorie nehmen keine paarige Anordnung der homologen Fäden in der frühesten Prophase der heterotypischen Kernteilung an. Die von den Anhängern der Spaltungstheorie als solche angenommenen Doppelfäden sind von ihnen als die Längsspaltung für die homöotypische Kernteilung gedacht worden. Sowohl die Längsspaltung als auch die Parallelanordnung der Kernfadens werden aber bei diesem Falle in demselben Stadium gleichzeitig beobachtet. So kann man nicht umhin, die Existenz dieser beiden Erscheinungen im frühesten Stadium der heterotypischen Kernteilung zu behaupten.

Im nächsten Knäuelstadium wird die Längsspaltung immer deutlicher (Fig. 7), während die zuerst genannte parallele Anord-

nung des Kernfadens eine grosse Verwirrung erfährt und schon in ,second contraction‘ Stadium schwer wahrnehmbar ist.

Da die Kernfadenschenkel, welche zunächst parallel angebracht worden sind, schliesslich gegenseitig nicht verschmelzen, fühlen wir uns genötigt zu behaupten, dass der Kernfaden in Knäuelstadium und darauffolgenden Stadien seiner Natur nach einfach ist und durch die ,Ende zu Ende‘ Verbindung der Fadensegmente d. i. Chromosomen ausgebildet ist.

Dann trennen sich die bisdahin einen kontinuierlichen Faden bildenden Fadensegmente voneinander ab. Durch die Verklebung ihrer eigenen freien Enden werden sie meistens schlingenförmig. Die Spiraldrehung lässt sich bei ihnen auch oft sehr schön ansehen.

Zur letzten Zeit haben Morgan und seine Schüler, auf die prachtvollen Ergebnisse ihrer geistreichen Versuche gestützt, eine Theorie über die Spiraldrehung des Kernfadens aufgestellt. Ob die bei *Chrysanthemum coronarium* vor sich gehenden Vorgänge zugunsten dieser Theorie stehen oder nicht, davon eine bestimmte Vorstellung hier zu geben bin ich nicht imstande. Jedoch wäre an dieser Stelle nur hinzufügen, dass bei *Chrysanthemum coronarium* die seitliche Berührung der homologen Fadensegmente nicht in Synapsis, sondern erst in ,second contraction‘ Stadium vorkommt, also irgend eine Wechselbeziehung zwischen den Fadensegmenten, wenn es gebe, ja auch in diesem Stadium ausgeführt werden müsste.

Ehe dieses Kapitel abgeschlossen wird, möchte ich es nicht unterlassen, der somatischen Kernteilung von *Chrysanthemum* einige Worte zu widmen. Um den Vergleich mit den meiotischen Phasen zu ermöglichen, habe ich jene an den Wurzelspitzen von *Ch. coronarium* studiert.

Selbstverständlich zeigt die somatische Kernplatte von dieser Pflanze 18 Chromosomen an (Taf. II, Fig. 7, 8.) Im nächsten Stadium weichen die Längshäften des einzelnen Chromosoms auseinander in der gewohnten Weise und bewegen sich nach den entgegengesetzten Polen zu (Taf. III, Fig. 9.) Inzwischen kommt die Längsspaltung der zu Pol gelangten Chromosomen scharf zum Vorschein (Taf. II, Fig. 11.) Diesähnliche Erscheinung ist in der letzten Zeit an den verschiedenen Pflanzen schon wiederholt gefunden worden, z. B. bei *Galtonia* (Digby, 1910), *Vicia* (Fraser und Snell, 1911) und *Cardiocrinum* (Takamine, 1915).

Beim nächsten Eintritt der Kernteilung treten wieder die paarweise angeordneten Chromatinkörner hervor (Taf. II, Fig. 3.) Diese Anordnung deutet aber nicht die Paarung der homologen Elemente an, sondern die Längsspaltung der einzelnen Element. In dieser Hinsicht scheint mir die Prophase der somatischen Kernteilung von der der heterotypischen scharf abzuweichen. Die Körnchen verkleben sich dann untereinander, um eine Anzahl Doppelfädchen auszubilden (Taf. II, Fig. 4). Das Doppeltsein des Fadens wird aber zeitlich undeutlich in der etwa mittleren Stufe des Knäuelstadiums. Zu erinnern wäre hier die entsprechende Erscheinung der meiotischen Kernteilung. Die in dem früheren Knäuelstadium der heterotypischen Teilung scharf hervorgetretene Längsspaltung des Kernfadens macht einen Rückschritt in dem ‚second contraction‘ Stadium. Die Längsspaltung ist bei der Metaphase dieser Teilung sehr schwer zu bemerken, während sie wieder bei der Prophase der homöotypischen Kernteilung ganz deutlich wahrgenommen wird.

Diese Beobachtungen führen uns zu der Überzeugung, dass die heterotypische Kernteilung ein in der Prophase der homöotypischen Kernteilung eingeschaltener Vorgang ist.

## 5. TETRADENTEILUNG DER POLLENMUTTERZELLE.

In den cytologischen Arbeiten sind Tetradenteilung und Reduktionsteilung bis jetzt öfters in demselben Sinne gebraucht worden. Im vorliegenden Aufsatz will ich aber die Tetradenteilung als eine gleich auf die Reduktionsteilung folgende Zellteilung definieren.

Hinsichtlich der Tetradenteilung der Pollen- bzw. Sporenmutterzelle kann man im gesamten Pflanzenreich überhaupt verschiedene Typen unterscheiden. Bei dem einen, der bei Dicotyledonen ganz verbreitet vorzukommen pflegt und am besten als der Dicotyledonen-Typus zu bezeichnen ist, wird die Zellwandbildung der Tetradenteilung ausschliesslich mittelst der unter den durch die Reduktionsteilung herbeigeführten vier freien Kernen eingelegten Zellplatten ausgeführt. Nicht nur bei Dicotyledonen, sondern auch bei Gymnospermen und Pteridophyten kommt fast ausschliesslich dieser Typus der Tetradenteilung vor.

Bei der Tetradenteilung der Pollenmutterzellen von den meisten Monocotyledonen wird die erste Scheidewand schon gleich nach der heterotypischen Kernteilung ausgebildet. Also gehen die homöotypischen Kernteilungen in den getrennten Zellen vor sich. Die zweite Scheidewandbildung kommt nach dieser Teilung vor. Diese zweimaligen Scheidewandbildungen lassen sich, wie bei dem ersten Typus, auch mittelst der Ausbildung der Zellplatten ausführen. Dieser Typus der Tetradenteilung wird im folgenden als der Monocotyledonen-Typus bezeichnet. Die Tetradenteilung bei den meisten Moosen wird auch nach diesem Typus vollzogen.

Bei dem dritten Typus, welcher bei der Tetrasporenbildung der Rhodophyceen vorhanden ist und infolgedessen Rhodophyceen-Typus genannt werden kann, wird die Scheidewand der Sporenmutterzellen, im Gegensatz zu den vorigen zwei Typen, nicht



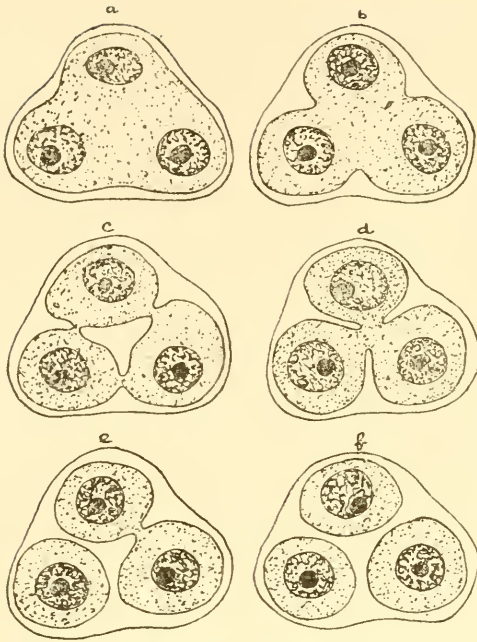
mittelst der Zellplattenbildung eingeschaltet. Am Anfang der Tetradenteilung dieser Zellen sieht man an vier untereinander tetraedrisch angeordneten Stellen kleine Wucherung der Zellwand. Diese Gebilde wachsen mehr und mehr nach dem Centrum der Zelle zu, um dort mit einander zu verschmelzen und die Zelle in vier getrennten Zellen d. i. Tetrasporen zu klüften.

Eigentümlicherweise findet man diesähnlichen Typus der Tetradenteilung bei einigen Dicotyledonen, Z. B. *Magnolia* (Guignard, 1808; Andrew, 1902) und *Anona* (Samuelson, 1914). Die Zellwandbildung bei der Tetradenteilung der Pollenmutterzellen von diesen Pflanzen wird auch ohne Begleitung von der Zellplattenbildung ausgeführt. Aber wie bei den Monocotyledonen kommt die erste Scheidewand schon gleich nach dem Ende der heterotypischen Kernteilung zu Tage. Diesen Typus der Tetradenteilung vermoehte ich auch bei *Magnolia conspicua* zu bestätigen.

Bekanntlich ähnelt auch die Tetradenteilung der Jungermaniales der der Rhodophyceen. Nämlich unterscheiden sich die Sporenmutterzellen von Jungermaniales von den der anderen Bryophyten dadurch, dass die Zerklüftung des Zelleibes schon lange vor dem Eintreten in die Reduktionsteilung ausgeführt wird. Die Zellwandbildung bei diesem Vorgang wird natürlich nach dem Rhodophyceen-Typus stattfinden. Die Zerklüftung aber unterbleibt in einer bestimmten Zeit der Entwicklung, um in Centralstelle der Sporenmutterzelle einen kleinen Raum zurückzubehalten, wo in den späteren Zeit die Reduktionsteilung vor sich geht. Die nach dem Ende der Reduktionsteilung vor sich gehende Zellwandbildung geschieht aber ganz nach dem Monocotyledonen-Typus.

Im Laufe meiner Untersuchung über die Pollenmutterzellen von verschieenen Chrysanthemen fiel es mir auf, dass diese Zellen ganz rein nach dem Rhodophyceen-Typus ihre Tetradenteilung aus-





Textfig. 6. Tetradenteilung der Pollenmutterzellen von *Chrysanthemum*.

zuführen pflegen. Dies ist in den nebenstehenden Figuren halb schematisch vergegenwärtigt worden. Die zur Untersuchung gezogenen allerlei Arten der Chrysanthemen führen ihre Tetradenteilung der Pollenmutterzellen sämtlich nach diesem Typus aus.

Es gelang mir merkwürdigerweise denselben Typus der Tetradenteilung auch bei einigen anderen Gattungen von Kompositen und einigen sonstigen Familien zu bestätigen.

Diesem Zustande nach zu urteilen, scheint mir dieser Typus der Tetradenteilung unter den Dicotyledonen etwas weit verbreitet zu existieren. Die ausführliche Behandlung von diesem Problem wird dem andern Orte vorbehalten.

## 6. SHASTA DAISY.

„Shasta Daisy“ ist eine Bastardpflanze, welche Luther Burbank vor Zeiten durch die Kreuzungen von verschiedenen *Chrysanthemum*-Arten erzielt hat. Infolge der Schönheit der Blüte sowie auch der Leichtigkeit der Kultur ist diese Pflanze jetzt fast auf der ganzen Welt verbreitet.

Wie bei dem Falle von anderen Bastarden giebt es auch viele Varietäten von dieser Pflanze, wovon einige seit etlichen Jahren auch in unsrem Lande auch eingeführt wurden. Ehe ich zur Be-

schreibung meiner Untersuchung betreffs der Reduktionsteilung in einer von diesen Varietäten komme, wird es nicht unzweckmässig sein, einige Bemerkungen über die Herkunft dieser Bastards voranzuschicken.

In dieser Hinsicht bringt das neulich erschienene Werk „Luther Burbank; His Method and Discoveries and their Application“ uns eine dankenswerte Nachricht. Es sagt:—

„The first few seasons of its (*Ch. Leucanthemum*) cultivation made no notable change of its appearance, nor indeed until after I had given it a new impetus by hybridizing it with an allied species.

„The plant with which the cross was made was a much larger and more robust species of daisy which I imported from Europe, which it is known colloquially as the ox-eye daisy, although the botanist gives it a distinct name, in recognition of its dissimilar appearance, calling it *Ch. maximum*. There is another continental daisy, by some botanists considered as a distinct species and named *Ch. lacustre* which is closely similar to the British species (*Ch. maximum*) and of this seeds were secured from a German firm.

„The cross was made first with the English daisy (*Ch. maximum*) by taking pollen from this flower to fertilize the best specimens of the American daisy (*Ch. Leucanthemum*)

„When the seeds thus produced were sown next season and the plants came to blooming time, it was at once evident that there was marked improvement.

„Further improvement was attempted by crossing the hybrid plant with the German daisy just referred to. A slight improvement was noticed but the changes were not very marked.

„In a meantime, I learned of an Asiatic daisy known to

botanist as *Ch. nipponicum* and I obtained the seeds of this plant from Japan. This Japanese daisy was in most respect inferior to the original American ox-eye with which these experiments had started. It is a rather coarse plant, with objectionable leafy stalk, and a flower, so small and inconspicuous that it would attract little attention and would scarcely be regarded by any one as a desirable acquisition for the garden.

„I crossed the best of my hybrid daisies with the pollen from the flowers of their Japanese cousin.

„After the five or six years' selection, at last the really wonderful flower that was since become known to all the world as the Shasta Daisy was produced.“

Dieser Beschreibung nach wurden vier Arten von *Chrysanthemum* zu diesem Experiment angewandt, d. i. *Ch. Leucanthemum*, *Ch. maximum*, *Ch. lacustre*, *Ch. nipponicum*. Was die letzt genannte Pflanze betrifft, kann aber darüber ein gewisser Zweifel herrschen. Die oben zitierten Beschreibungen über diese Pflanze scheinen in der Tat nicht mit der wahren Beschaffenheit dieser Pflanze übereinzustimmen. Zum Beispiele über die Blüten schreibt es: „Flowers so small and inconspicuous that it would attract little attention.“ Doch hat das Köpfchen von *Ch. nipponicum* die grösste Dimension unter den japanischen *Chrysanthemum*-Arten. Also bin ich fest überzeugt, dass die Pflanze aus Japan, welche Luther Burbank bei der Herstellung von Shasta Daisy seiner Zeit angewandt hat, nicht *Ch. nipponicum* sein wird. Dann ist es ein dringendes Problem nach einer anderen Pflanze umzusehen, welche allem Anschein nach dem zur Burbanks Verfügung gestellten Gewächse entsprechen könnte. In dieser Hinsicht ist *Ch. arcticum* eine Aufmerksamkeit erregende Pflanze. Das ganze Aussehen von dieser Pflanze ähnelt dem von *Ch. Leucanthemum*, sowie auch dem von *Ch. maximum*

in einem solchen Grade, dass man mit Burlank sie richtig als ‚Japanese Daisy‘ nennen dürfte. Die oben hervorgehobene Beschreibung über Burkanks ‚Japanese Daisy‘ stimmt mit den Eigenschaften von diesem Pflänzchen genau überein. Mit voller Wahrscheinlichkeit kann man also annehmen, dass die Pflanze aus Japan, welche an der Ausbildung von Shasta Daisy teilgenommen hat, *Ch. arcticum* sei.

Soweit habe ich über die Entstehung von Shasta Daisy gesprochen. Nun gehe ich auf die Beschreibung der Reduktionskernteilung in den Pollenmutterzellen von dieser Pflanze über. Sie hat einen sehr grossen Kern. Das Ruhestadium von diesem Kerne zeigt eine feinkörnige Struktur. Die als Prochromosomen anzusehenden Gebilde lassen sich bei dieser Pflanze auch nicht wahrnehmen. In der Prophase der heterotypischen Kernteilung liegt das gewöhnliche Synapsisstadium vor (Fig. 1. Taf. III.) Die Parallelanordnung der Fäden, welche wir bei *Ch. coronarium* deutlich wahrnehmen können, kann aber hier nicht so deutlich beobachtet werden. Dies rührt wahrscheinlich von der schwächeren Anziehungskraft der Kernfäden von dieser Pflanze her. Die Längsspaltung des Fadens ist schon in der Spätsynapsis sichtbar. Darauf folgt das Knäuelstadium. Der lange kontinuierliche Faden läuft den ganzen Kernraum hin und her durch. Wie die Figuren von Taf. III. zeigen, ist der Faden in der Prophase der heterotypischen Kernteilung von dieser Pflanze ganz gleichdickig ausgebildet. Dies sollte einen grossen Rückhalt an der Annahme geben, dass der Kernfaden der heterotypischen Prophase von dieser Pflanze univalent sei, weil wir wie unten beschreiben, neben den gepaarten Chromosomen noch eine Anzahl ungepaarte Chromosomen vor uns haben. Rosenberg (1909) hat bei seiner Untersuchung an den *Drosera*-Hybriden das Augenmerk auch auf diesen Punkt gerichtet.

Doch gelang es ihm nicht, zu einem bestimmten Resultate zu kommen. Bei der Spät-Diakinese konnte man die Spaltungslinie nicht mehr ersehen. Fig. 5 Taf. III. zeigt eine Seitenansicht der heterotypischen Kernplatte, wo man einen deutlichen Unterschied an Grösse und Forme der Chromosomen wahrnehmen kann. Der Form und Grösse nach dürfte man glauben, dass ein nicht zu kleiner Anteil von diesen Chromosomen univalent sei. Für die Polansicht derselben Kernplatte verweise ich auf Fig. 4, Taf. III. Die Zählung der Chromosomen geschah wie gewöhnlich bei solcher wiederholten Besichtigung der Kernplatte. Die Zählung der Chromosomen ist hier jedoch einer Schwankung zwischen 80–90 unterworfen. Die ähnliche Schwankung der Chromosomenzahl kommt auch bei der homöotypischen Kernteilung vor (Fig. 6, Taf. III.). Die Zahl schwankt hier aber zwischen 60–70. Wenn man die durchschnittlichen Zahlen der Chromosomen in der hetero- und der homöotypischen Kernteilung als 85 und 65 annimmt, lässt sich dann der folgende Schluss daraus ziehen, dass von 85 Chromosomen der heterotypischen Kernplatte 45 bivalent und 40 monovalent seien. Das erinnert uns an dieser Stelle an die Chromosomenzahl von *Ch. arcticum*, einer Pflanze, welche meiner Ansicht nach zur Ausbildung von diesem Bastard benutzt sein dürfte.

Das Verhalten der Chromosomen bei heterotypischen Metaphase von den Bastardwesen ist von verschiedenen Forschern schon wiederholt untersucht worden. Beim Bastarde zwischen *Drosera longifolia* mit 20 kleineren Chromosomen und *Drosera rotundifolia* mit 10 grösseren Chromosomen liegen nach Rosenbergs Untersuchung auch bei der heterotypischen Metaphase in den Pollenmutterzellen bivalente und univalente Chromosomen nebeneinander vor.

Bei den *Oenothera*-Hybriden behauptet Gates (1909, 1915), dass zwischen den 7 Chromosomen von *Oe. lata* und 14 von *Oe.*



*gigas* keine Konjugation stattfindet; diese 21 Chromosomen verteilen sich in der heterotypischen Anaphase so, dass 10 auf den einen 11 auf den anderen Pol kommen. Geerts (1911) dagegen hat gezeigt, dass die heterotypische Kernplatte des genannten Bastards 7 bivalente und 7 univalente Chromosomen aufweise, indem also die 7 *lata*- mit 7 *gigas*-Chromosomen konjugieren.

Anzuführen wäre noch ein Fall von der zoologischen Seite. Das Verhalten der Chromosomen bei der heterotypischen Metaphase des Bastards zwischen *Pygæra*-Arten ist nach Federley (1913) sehr eigentümlich. Er schreibt: „In der Prophase der ersten Reifungsteilung kommt entweder gar keine Konjugation der artfremden Chromosomen vor oder eine solche von einzelnen Chromosomenpaaren. Im ersten Falle gehen alle Chromosomen selbständig in die Kernspindel ein, welche also die diploide Chromosomenzahl aufweist. Die Chromosomen teilen sich alle äquationell. Eine Chromosomenreduktion findet also nicht statt. Werden dagegen diejenigen Fälle, in welchen eine Konjugation zwischen einzelnen Chromosomenpaaren geschieht, mit in Betracht gezogen, so ist die erste Reifungsteilung eine kombinierte Äquations- und Reduktionsteilung.“

Federleys Ergebniss weicht entschieden von dem erst genannten Fall von *Drosera*-Bastard darin ab, dass die ungepaarten Chromosomen bei der heterotypischen Kernplatte nicht als ganzes zu dem einen oder anderen Pole gezogen werden, sondern wie gewöhnliche somatische Kernteilung längsgespaltet und jede Hälfte an jedem Pole verteilt werden. Da wir die Chromosomenzahlen von allen zur Bastardierung von Shasta Daisy benutzten Pflanzen nicht kennen, kann das Nähere über das Chromosomenverhalten bei der Reduktionskernplatte von Shasta Daisy leider nicht diskutiert werden. Doch scheint es mir die Reduktionskernplatte von diesem Bastarde eine grosse Gemeinsamkeit mit der von *Drosera*-Bastard zu zeigen.



Wie bekannt, kommen die Anomalien der Pollenentwicklung häufig bei den Bastardpflanzen vor. Die Unregelmässigkeit der Tetradenteilung tritt aber bei Shasta Daisy nicht so deutlich zu Tage. Fast alle Chromosomen werden zu dem einen oder dem anderen Pole gezogen. Die Pollenmutterzelle wird in der Regel in der vier normal aussehende Pollenkörner zerteilt. Doch kann man bei diesem Falle auch gewisse Verschiedenheit der Grösse von Pollenkörnern bemerken.

Zum Schluss dieses Abschnittes möchte ich in grösster Kürze meine Beobachtungen bezüglich des japanischen Garten-Chrysanthemums und *Ch. frutescens* beschreiben.

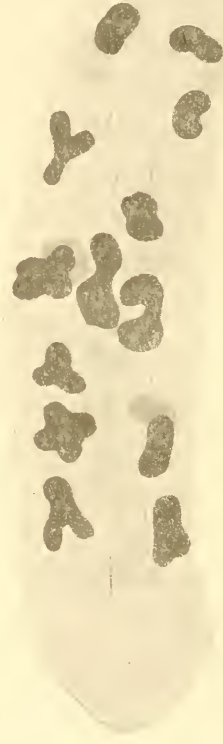
Seit langen Jahren wird es gesagt, dass die jetzigen zahlreichen sogenannten japanischen Garten-Chrysanthemen von einer in Asien wild-wachsenden *Chrysanthemum*-Art, *Ch. morifolium* (*Ch. chinensis*) abstammend seien. Den Beweis hierfür bringt uns in erster Linie das Aussehen vieler japanischen Garten-Chrysanthemen, welche mit dem von *Ch. morifolium* eine ausgeprägte Ähnlichkeit aufzuweisen pflegten. Ferner kann hier der zweite Beweis von der cytologischen Seite geführt werden.

Um die Chromosomenzahl von den japanischen Garten-Chrysanthemen zu untersuchen, fixierte ich die zahlreichen Köpfchen von verschiedenen Gartenvarietäten. Aber die Fixierung fiel meist ganz schlecht aus. Doch kann das folgende hier mit Bestimmtheit angegeben werden, dass die vielen Varietäten von japanischen Garten-Chrysanthemen meiner Forschung nach dieselbe Chromosomenzahl mit *Ch. morifolium* besitzen.<sup>1)</sup>

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1) Es giebt auch die anderen, welche mehr als 27 Chromosomenzahl besitzen. Zum Beispiele hat die eine Art als die reduzierte Chromosomenzahl 36 aufzuweisen. Diese Tatsache scheint es mir zu verraten, dass eine Anzahl Arten von *Ch. Decaisneanum* abstammend sein und auch die anderen durch die Kreuzungen zwischen den Arten mit 27 und 36 Chromosomen ausgebildet sein sollten.

*Chrysanthemum frutescens* ist auch eine ganz verbreitete Gartenpflanze. Bei dieser Pflanze geht die meiotische Kernteilung so unregelmässig vor sich, dass die hetero- und die homöotypische Kernplatte in Bezug auf die Embryosack- und Pollenmutterzelle in der Tat kaum eine entscheidende Bestimmung der Chromosomenzahl zulassen. Die nebenstehende Textfig. 7 zeigt die Seitenansicht der heterotypischen Kernspindel in einsr Embryosackmutterzelle von dieser Pflanze. Dort sieht man eine ausserordentlich lang. ausgedehnte Spindel, in welcher etwa zwanzig Chromosomen ordnungslos zerstreut liegen. Da in der meiotischen Kernplatte der Pollenmutterzellen noch niedrigere Chromosomenzahl stets gefunden wird, müssten einige von diesen zahlreichen Chromosomen in der Spindel der Embryosackmutterzelle als univalent gedacht werden. Ich habe vergebens noch die Chromosomenzahl von dieser Pflanze bei den somatischen Kernplatten zu bestimmen gesucht.



Textfig. 7. Seitenansicht der heterotypischen Kernspindel in der Embryosackmutterzelle von *Chrysanthemum frutescens*.

( $\times 2700$ )

### III. *Erigeron*.

#### 1. PARTHENOGENESIS bei *Erigeron annuus* Pers.

Die Bezeichnung Parthenogenesis ist heute noch von mehreren Forschern nicht immer in übereinstimmenden Sinne gefasst worden

Im folgenden wollen wir unter dieser Bezeichnung eine ungeschlechtliche Entstehung eines Sporophyten aus dem Ei verstehen, dessen Chromosomenzahl je nach dem Falle diploid oder haploid sein kann.

Diese Erscheinung war schon in ganz früherer Zeit bei Tier- und Pflanzenreich ziemlich wohl bekannt. Aber bei den Blütenpflanzen, wenn auch das Vorkommen hier und da schon lange behauptet worden war, hatten wir keinen unzweifelhaften Fall bis zum Ende des letzten Jahrhunderts. Doch lieferte schliesslich die im Jahre 1900 erschienene bekannte Arbeit von Juel über die Parthenogenesis bei *Antennaria alpina* den Ausgangspunkt für die Untersuchung über dieses interessante Problem. Viele wichtigste Arbeiten folgten ihr auf dem Fusse hinter einander. Indessen ist die Zahl der Pflanzen, bei welchen die Parthenogenesis sicherlich nachgewiesen worden ist, jetzt noch sehr niedrig. Solche Pflanzen sind in den verschiedenen Familien verteilt. Aber bemerkenswerter Weise ist der grosse Teil von ihnen in den Kompositen zu finden, nämlich ;—

*Saururaceae*

*Houttuynia* (Shibata u. Miyake, 1908)

*Urticaceae*

*Elatostema* (Strasburger, 1910)

*Ranunculaceae*

*Thalictrum* (Overton, 1904)

*Rosaceae*

*Alchimilla* (Murbeck, 1901 ; Strasburger, 1905)

*Thymeläaceae*

*Wikstroemia* (Winkler, 1906 ; Strasburger, 1909)

*Kompositae*

*Antennaria* (Juel, 1900)

*Taraxacum* (Juel, 1905)

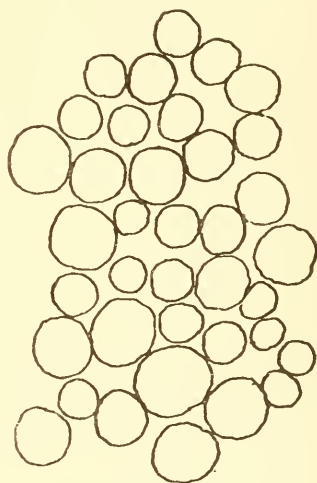
*Hieracium* (Rosenberg, 1907)

*Chondrilla* (Rosenberg, 1912)

*Eupatorium* (Holmgren, 1916)

*Erigeron annuus* Pers. ist eine Pflanze von erstauntlicher Verbreitung. Es ist um dreissig Jahre her, seit diese Pflanze zuerst in Japan eingeführt worden ist. Gegenwärtig wurde sie aber eins von den gemeinsten Unkräutern mindestens in den Umgebungen von Tokio, wo die ausgedehnten Plätze oft fast nur von dieser Pflanze wuchern. Die Blütezeit von diesem Gewächse ist ziemlich lang, dauert vom Frühsommer bis zum Spätherbst. Das Köpfchen, etwa 1.6 cm im Durchmesser, besteht aus Scheiben- und Randblüten. Die letzteren sind weissfarbig. Ungeachtet des Vorkommnis der Parthenogenesis ist die Samensetz bei dieser Pflanze sehr reichlich.

Die Reduktionskernteilung und Tetradenteilung in den Pollenmutterzellen gehen in etwas abnormaler Weise vor sich, wie bei den Fällen von anderen parthenogenetischen Pflanzen. Diese Zellen teilen sich in zwei, drei oder mehr. In Zusammenhang damit ist die Grösse der Pollenkörner verschiedenartig; die riesigen und winzigen Pollenkörner befinden sich im bunten Gemisch in demselben Pollensacke (Textfig. 8).



Textfig. 8. Pollenkörner von *E. annuus*. ( $\times 400$ .)

Diesähnliche Erscheinung ist wiederholt bei anderen parthenogenetischen Pflanzen beschrieben worden. Die feineren Vorgänge der Reduktionsteilung in den Pollenmutterzellen sind in Fig. 1–7 Taf. IV. zur Darstellung gebracht. Fig. 1 zeigt die früeste Prophase der

heterotypischen Kernteilung. Die paarweise Anordnung der feineren Kernfäden ist klar sichtbar. Dieselbe Anordnung ist in Synapsis sowie auch in Spirem deutlich zu ersehen. Und die wirkliche Längsspaltung des Kernfadens ist wie bei *Ch. coronarium* ja auch schon in Synapsis-Stadium bemerkbar (Fig. 2).

Fig. 4 Taf. IV zeigt einen Kern in Diakinesis. Die Zählung der Gemini ist etwas schwierig, nicht nur bei diesem Stadium, sondern auch bei der darauf folgenden Metaphase. Dies rührt von der unregelmässigen Anordnung der Gemini bei dieser Teilung her. Die Pol- und Seitenansicht der Kernplatte sind in Fig. 5 u. 6 Taf. IV vergegenwärtigt worden. Wie diese Figur zeigt, giebt es deutlichen Unterschied unter den Grössen und Gestalten der Gemini. Über die somatische Chromosomenzahl von dieser Pflanze ist aber leicht ein bestimmter Schluss an deren Wurzelspitzen zu ziehen. Fig. 8 Taf. IV veranschaulichen die Polansichten der Kernplatten von dieser Teilung. Dort kann man ohne weiteres 26 Chromosomen abzählen.

Es ist eine bemerkenswerte Tatsache, dass die Chromosomen bei dieser Platten paarweise sich deutlich anzuordnen pflegen. Diese Erscheinung wurde schon mehrfach an den normal geschlechtlichen Pflanzen beobachtet und neulich auch an einer parthenogenetischen Pflanze, *Elatostema sessile*, von Strasburger (1910) entdeckt. Hierüber schreibt er folgendermassen:—

„Die Chromosomenpaare der Kerne solcher apogamen Pflanzen, wie *Elatostema sessile*, müssen von den homologen Chromosomen der Ureltern abgeleitet werden, so weit der sexuelle Vorgang, der sie zusammenführt, phylogenetisch auch zurückliegen mag. In den Vegetationspunkten einer 5000 Jahre alten *Sequoia gigantea* würden die homologen Chromosomen in solchen Paaren auch nicht eben jungen Ursprungs sein.“



Bei den parthenogenetischen Pflanzen wird die homöotypische Kernteilung der Pollenmutterzellen öfters vernachlässigt. Aber bei *Erigeron annuus* findet man diesen Vorgang in den meisten Pollenmutterzellen. Jedoch geht diese Teilung auch wie bei der heterotypischen Teilung in etwas unregelmässiger Weise vor sich. Die durch diese Teilung in einer Zelle entstehenden Kerne sind in der Zahl nicht konstant; sie kann drei, vier, fünf oder mehr sein.

Die fertigen Pollenkörner haben nur einen Kern, während die normal-geschlechtlichen *Erigeron*-Arten zwei Kerne enthalten, wie bei den meisten Fällen der Dicotyledonen.

Nun will ich auf Schilderung über die Embryosackentwicklung bei *Erigeron annuus* übergehen. Der jugendliche Nucellarhöcker zeigt in seinem Centrum eine grosskernige Archespore. Die die Archespore umgebende Nucellarschicht ist nur einzellig. Ohne Ablagerung von Schichtzelle wird die Archespore direkt zur Embryosackmutterzelle. Der Kern dieser Zelle geht inzwischen zum Vorbereitungsstadium für die Reduktionsteilung über. Die feineren Kernfäden reihen sich deutlich an einander, wie bei den Pollenmutterzellkernen (Fig. 9, Taf. IV). In Synapsis und Spirem kann man kein die Ausschaltung der Reduktionsteilung andeutendes Anzeichen beobachten. Die homologen Kernfedenschenkel kommen für immer nicht zur engeren Berührung. Indessen kann diese Erscheinung auch bei den geschlechtlichen Pflanzen ersehen werden.

Die Vernachlässigung der Reduktionskernteilung bei den parthenogenetischen Pflanzen kommt in verschiedenem Grade vor. Die neueren Untersuchungen zeigten, dass bei einigen Fällen die Synapsis selbst nicht mehr beobachtet werden. Die meisten parthenogenetischen Pflanzen führen aber wenigstens die Synapsis aus; und an diese Erscheinung ist die grosse Bedeutung von einigen Forschern verknüpft worden. Aber heute noch haben wir



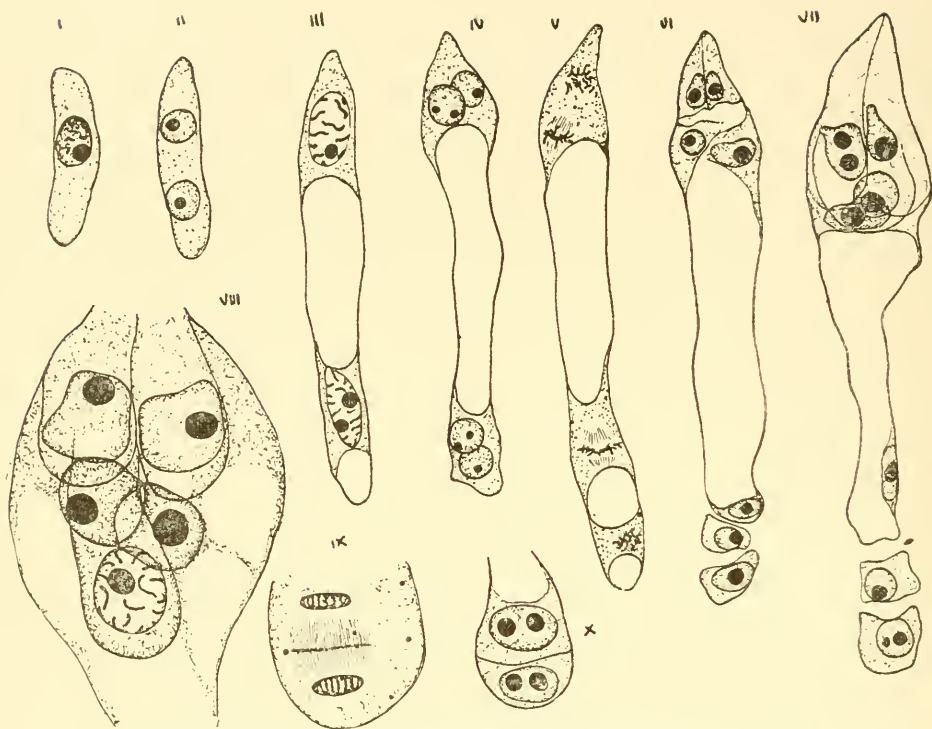
keine sichere Kenntniss über das Wesen der Synapsis von normalgeschlechtlichen Pflanzen. Die eingehende Diskussion über die Synapsis von parthenogenetischen Pflanzen sollte also auch dahin gestellt bleiben.

Erst im späteren Diakinesenstadium tritt ein die Parthenogenesis hindeutendes Anzeichen deutlich zum Vorschein. Die bis dahin zu Gemini gepaarten Chromosomen entfernen sich auseinander und verteilen sich gleichmässig an die Kernwandung. Ich verweise hierfür auf die Fig. 13, Taf. IV. Das Spindelstadium, das darauf nachfolgt, ist in Fig. 14, Taf. IV dargestellt. Die Spindelbildung ist dort noch nicht fertig. Die Chromosomen liegen in Spindelfasern zerstreut. Für die Zählung der Chromosomen ist aber dieses Stadium besonders geeignet. Etwa 26 Chromosomen lassen sich in jedem Falle abzählen. Die Spindel in solchem Zustande wird mindestens in meinen Präparaten besonders häufig gefunden. Der Teilungsvorgang scheint in diesem Zustande ziemlich lang anzudauern. Die fertige Spindel kann doch nur selten gesehen werden.

In der Telophase der heterotypischen Kernteilung tritt die Zellplatte sehr deutlich hervor. Aber in noch späterem Zustande erlischt sie nach und nach. Die zwei Kerne liegen dann ganz frei in demselben Cytoplasma. Die in dieser Weise entstandenen zwei Kerne beteiligen sich sämtlich an der Ausbildung des Embryosackes. Die einstige Embryosackmutterzelle kann jetzt Embryosackanlage genannt werden.

Unterdessen verlängern sich diese Zellen weiter und weiter. Die zwei Kerne weichen nach jedem Pole zu auseinander, indem ein grosser Saftraum im Centrum der Zelle entsteht.

Während dieser Entwicklung des Embryosackes löst sich die Nucellarschicht allmählich auf. Die Spitze des nackten Protoplasmas des Embryosackes tritt dann in direkte Berührung mit Integument.



Textfig. 9. Embryosackentwicklung von *Erigeron annuus*. Erklärung im Text. ( $\times 630$ )

Inzwischen findet sich die zweite Kernteilung in Embryosack statt. In Prophase dieser Kernteilung wurden etwa 26 Chromosomen im Kernraum abgezählt. Die Zellplatte tritt wieder deutlich bei Telophase dieser Teilung hervor. Die wirkliche Teilungswand entsteht aber auch nicht.

Nach einem Zeitraum führen die zwei mikropylaren Kerne die dritte Kernteilung aus. Dabei können wir wieder beobachten, dass die Kerne des Embryosackes bestimmt mit den diploiden Chromosomen ausgestattet sind. Ich verweise hierfür auf Fig. 21 Taf. IV, welche die Polansicht der Kernplatte dieser Teilung darstellt. Fast für immer ordnen sich die zwei micropylaren Spindeln in zwei Etagen an. Die obere Spindel schneidet die Längs-

achse des Embryosackes mehr oder weniger rechtwinklig, während die untere in der Richtung dieser Achse sich orientiert (Textfig. 9, V). Die am Ende dieser Teilung sich bildende Zellplatte wird diesmal von der Ausbildung der wirklichen Zellwand begleitet. Dadurch entstehen eine Eizelle und zwei Synergiden (Textfig. 9, VI).

Die Teilungsvorgänge in dem micropylaren Ende gehen in dieser Weise ganz normal vor sich. Doch weisen die in Antipodalende keine Regelmässigkeit auf. Das dominierende Verhalten in meinem Material war aber, dass der obere Antipodalkern—wie die Figur zeigt, reihen sich die zwei Antipodalkerne im unteren Ende des Embryosackes auch in zwei Etagen an—die dritte Kernteilung ausführt, während sich der untere Antipodalkern für immer nicht zur Teilung anschickt. Also in dem Antipodalende entstehen für gewöhnlich drei Kerne, wovon der oberste als der untere Polkern fungiert (Textfig. 9, VI). Es kommt aber auch in vereinzelten Fällen vor, dass der untere Antipodalkern, wie der obere, die dritte Kernteilung in der gewohnten Weise ausführt.

Die parthenogenetische Embryosackentwicklung von *Elatostema acuminatum* zeichnet sich auch durch ihre Regellosigkeit aus. Hinsichtlich dieser Erscheinung schreibt Strasburger (1910) folgendermassen. „Bei den bisher studierten apogamen Angiospermen zeigten sich die Entwicklungsvorgänge im Embryosack durch die Diploidie der Kerne nicht beeinflusst. Bei *Elatostema acuminatum* scheint es hingegen, als wenn sie durch die Diploidie gestört werden.“ Doch ob diese Erscheinung wirklich in einer Beziehung mit Parthenogenesis steht oder nicht, sollte dahingestellt bleiben.

Bei den parthenogenetischen Pflanzen vielfach kommen die zwei Polkerne nicht zur Verschmelzung. So verhalten sich zum Beispiele die Polkerne von *Antennaria alpine* (Juel, 1900). Bei

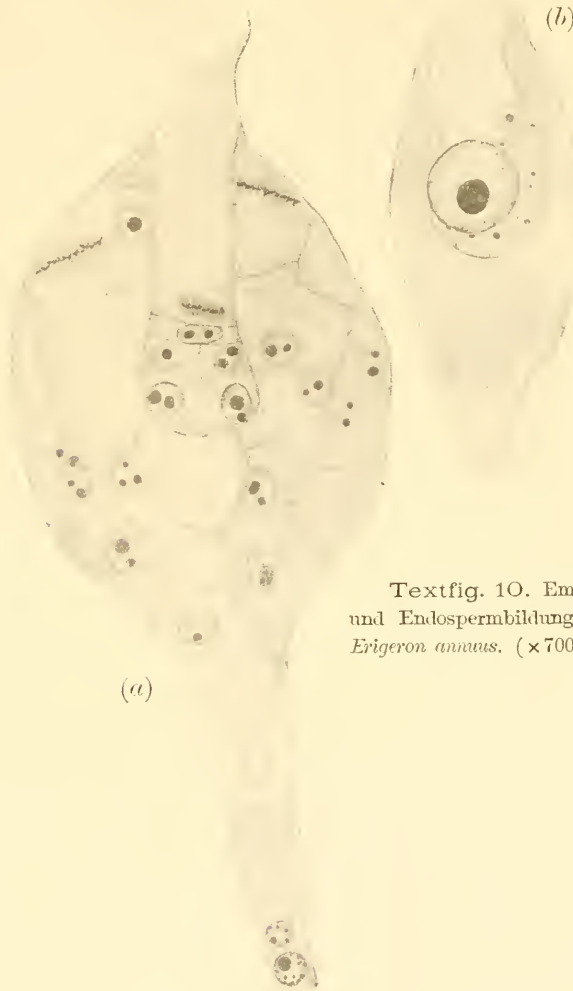
*Erigeron annuus* aber pflegen sich die zwei Polkerne unmittelbar unter der Eizelle zu vereinigen. Die zwei Polkerne schliessen dabei fast immer eine Menge Cytoplasma zwischen ihnen ein. Das geschlossene Cytoplasma lässt sich im späteren Zustande noch wahrnehmen (Textfig. 9, VIII; Taf. IV, Fig. 15–17.). Dieselbe Erscheinung ist auch bei *Peperomia sintesii* von Brown (1910) und bei *Gagea lutea* von Nemec (1912) beobachtet worden.

Die erste Endosperm-Kernteilung findet für gewöhnlich nach der vollständigen Verschmelzung der Polkerne statt. Aber es kommen auch die Fälle vor, wo die erst in Berührung sich befindenden zwei Polkerne bereits ein Vorstadium der Kernteilung aufweisen (Taf. IV, Fig. 16). Bei der Metaphase von der ersten Endosperm-Kernteilung treten um 52 Chromosomen auf, also die syndiploidische Chromosomenzahl von dieser Pflanze. Fig. 18 u. 19 Taf. IV behandeln die zwei aufeinander folgenden Schnitte derselben Kernplatte von dieser Kernteilung. Es kommt dieselbe Chromosomenzahl auch in den späteren Zuständen der Endosperm-bildung vor. Fig. 20 Taf. IV zeigt eine Polansicht einer Kernteilung in vielzelligem Endosperm.

Die Embryobildung von dieser Pflanze geht nach dem gewöhnlichen Modus der Dicotyledonen vor sich. Textfig. 9, IX stellt eine Telophase der ersten Teilung des Eikerns dar; mehrere extranucleare Nucleolen befinden sich zerstreut in Cytoplasma. Den zweizelligen Zustand des Embryos bildete ich in Textfig. 9, X ab.

Bei den parthenogenetischen Pflanzen vielfach, in Zusammenhang mit dem Fehlen der Doppelbefruchtung, schreiten die Embryobildung und Endosperm-bildung in verschiedenen Anordnungen vor. Bei *E. annuus* auch tritt die Endosperm-bildung bald früh, bald sehr spät ein. Die zwei nebeneinander stehenden Figuren veranschaulichen die Sache in voller Klarheit. In Textfig. (10, a) gehen

die Embryobildung und Endosperm Bildung Hand in Hand vor sich, während sich in Textfig. (10, b) der Endospermkern, trotz des vielzelligen Zustandes des Embryos, noch in Ruhestadium befindet,



Textfig. 10. Embryo-  
und Endosperm Bildung von  
*Erigeron annuus*. ( $\times 700$ )

## 2. GESCHLECHTLICHE EMBRYOSACKENTWICKLUNG BEI *Erigeron linifolius* Wild.

Die neueren Studien über die pflanzlichen Parthenogenesis

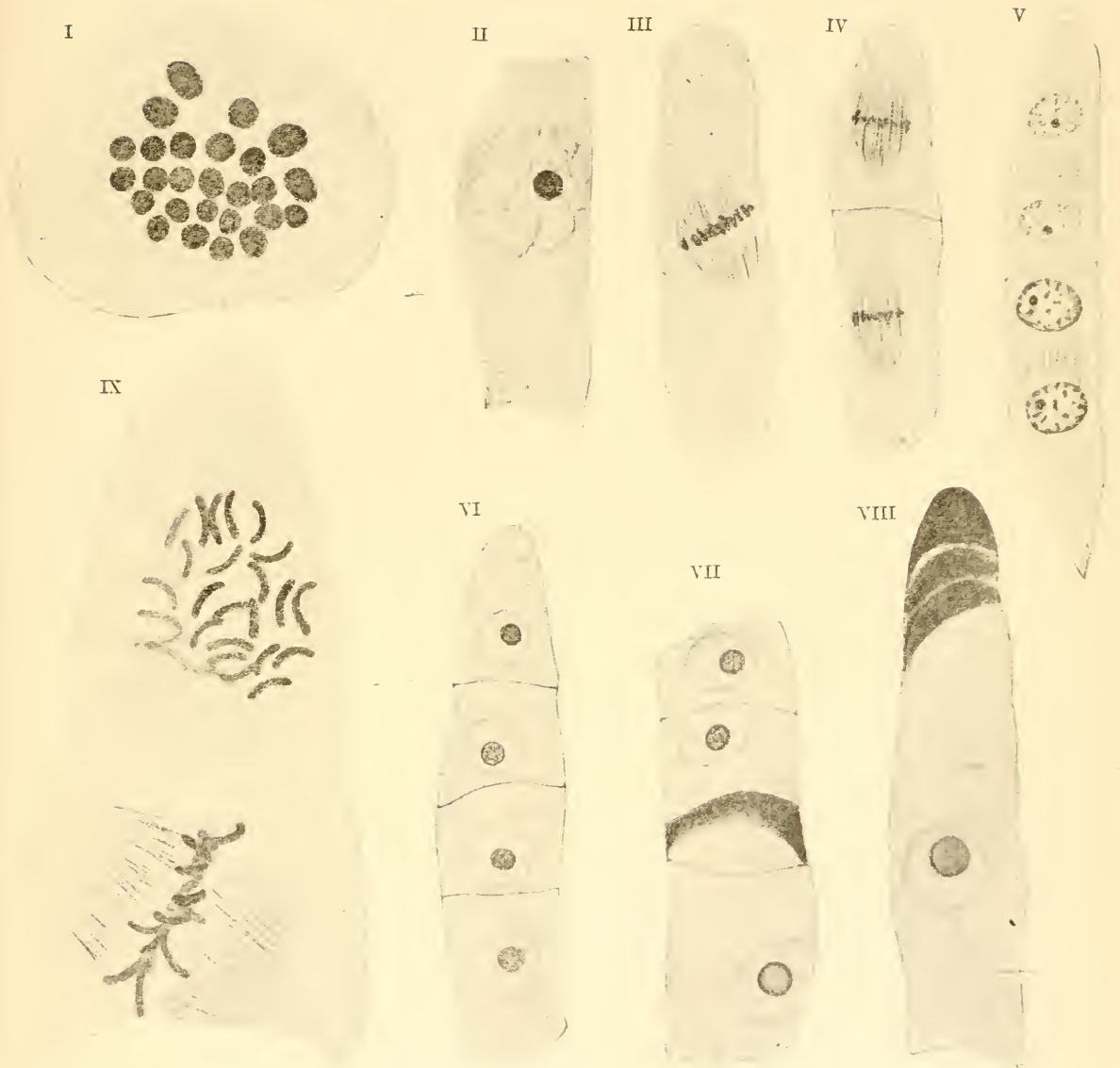


lehren uns, dass die parthenogenetischen und die geschlechtlichen Fortpflanzungen in ein und derselben Gattung oft vorkommen können. So kann man von Anfang an natürlich vermuten, dass eine Anzahl Species von *Erigeron* geschlechtliche Fortpflanzung ausführen. Schon hat ja im Jahre 1900 Land die Doppelbefruchtung bei *Erigeron philadelphicus* beschrieben. Es gelang mir auch solche Fälle bei *E. linifolius* und *E. dubius* nachzuweisen. Unten werde ich zuerst die geschlechtliche Embryosackentwicklung bei *E. linifolius* beschreiben.

*E. linifolius* Willd ist auch bei uns nicht einheimisch. Aber gegenwärtig weist sie eine grosse Verbreitung in ganz Japan auf. Diese Pflanze unterscheidet sich von *E. annuus* durch ihre Chromosomenzahl. Wie schon oben erwähnt, beträgt die Diploidechromosomenzahl von *E. annuus* 26, während die von *E. linifolius* etwa 52 beträgt. Nämlich ist die Chromosomenzahl von dem letzteren doppelt so viel als die des ersteren. Die Reduktions- und die Tetradenteilung in den Pollenmutterzellen gehen regelmässig vor sich. Die Zahl der Gemini in der heterotypischen Metaphase beträgt 26 (Textfig. 11, I.).

Die Embryosackmutterzelle kommt hier auch als eine subepidermale Zelle des Nucellarhöcker vor. Die meiotische Kernteilung und die darauf folgende Tetradenteilung von dieser Zelle werden nach der gewohnten Weise ausgeführt. Aus dieser Teilung entstehen die in einer Reihe sich anreihenden vier Megasporen. Die unterste davon vergrössert sich weiter und weiter, um einen fertigen Embryosack auszubilden. Die darüber befindlichen drei anderen Megasporen werden dabei absald verdrängt. Diese Entwicklungsvorgänge deuten schon die geschlechtliche Fortpflanzung von dieser Pflanze deutlich. Sie sind im einzelnen in Textfig. 11 veranschaulicht werden.

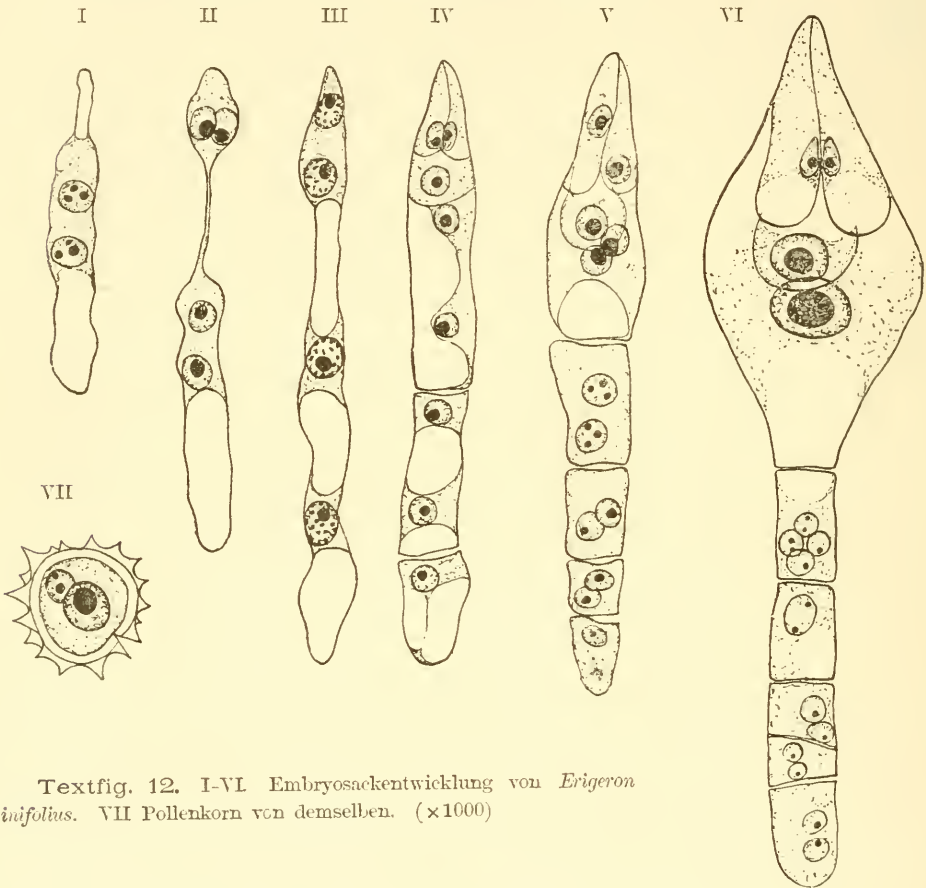




Textfig. 11. Pollen- und Embryosackentwicklung von *Erigeron linifolius*. 1, Heterotypische Metaphase in der Pollenmutterzelle. ( $\times 4000$ ) II—VIII, Tetradenteilung von Embryosackmutterzelle. ( $\times 1500$ ). IX Dritte Kernteilung im Embryosack. ( $\times 4000$ ).

Dann werden, wie bei den üblichen Fällen, die dreimaligen Kernteilungen im Embryosack ausgeführt (Textfig. 12). Bei diesen

Kernteilungen konnte ich mit Bestimmtheit die Haploidie der Embryosackkerne beobachten. Textfig. 11, IX zeigt den Längsschnitt vom oberen Ende des Embryosackes, wo sich nun beide dritte Kernteilungen in der Metaphase befinden.



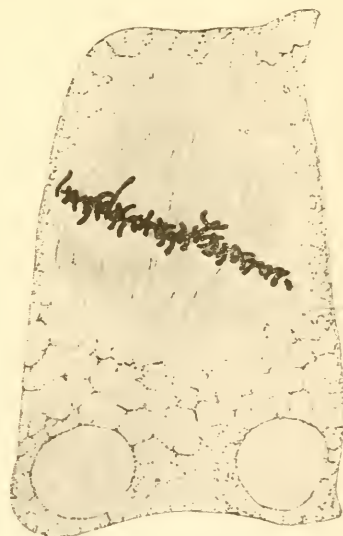
Textfig. 12. I-VI Embryosackentwicklung von *Erigeron linifolius*. VII Pollenkorn von demselben. ( $\times 1000$ )

Der fast fertige Embryosack wird in Textfig. 12, IV vergewärtigt. Dort finden wir zwei Synergiden, eine Eizelle, zwei Polkerne und zwei Antipodalzellen; die obere von den letzteren ist fast für immer zweikernig. Die zwei Kerne in dieser Zelle verschmelzen dann jedoch für gewöhnlich zu einem grossen Kerne, welcher in noch späterem Zustande eine abermalige Kernteilung

ausführt. Aber öfters kommt der Fall vor, dass die zwei Kerne der oberen Antipodalzelle ohne Verschmelzung je eine Kernteilung unternehmen. In diesem Falle sehen wir vier Kerne in derselben Zelle. Diese vier Kerne scheinen aber auch im nächsten Stadium zu einem grossen Kerne zu verschmelzen. Auf jeden Fall weist die Kernteilung des verschmolzenen Kerns bedeutend grössere Chromosomenzahl auf. Bei der weiteren Entwicklung werden die ähnlichen Vorgänge vielfach wiederholt, nicht nur in der oberen, sondern auch in der unteren Zelle. Und schliesslich entsteht eine lange Reihe von Antipodalzellen, welche je ein, zwei oder mehr Kerne in sich schliessen (Textfig. 12, VI). Textfig. 13 zeigt eine Seitenansicht von einer Kernplatte in einer Antipodalzelle, wo die Chromosomen von ungeheurer Anzahl gedrängt zum Vorschein kommen. Es kann nicht bezweifelt werden, dass die Funktion der Antipodalzellen eine Ähnlichkeit mit der Tapetenzellen von Antheren hat. Die oben geschilderte Erscheinung bei den Antipodalzellen wurde schon vielfach in den Tapetenzellen von mehreren Pflanzen beobachtet, z. B. bei *Wikstroemia* (Winkler, 1906; *Morus* Tahara, 1910.)

Textfig. 12, VI weist einen ganz fertigen Zustand des Embryosackes auf. Im Vergleich mit dem Falle bei *E. annuus* ist die Grösse des Synergidenkerns bedeutend kleiner. Der angeschwollene Zustand des Synergidenkerns von *E. annuus* dürfte etwaige Beziehung zur parthenogenetischen Fortpflanzung dieser Pflanze haben.

Zu meinem Bedauern war ich nicht



Textfig. 13. Kernteilung in einer Antipodalzelle von *Erigeron unifolius*. ( $\times 2700$ )

imstande, den Befruchtungsvorgang von *E. linifolius* in Wirklichkeit zu beobachten. Aber aus dem oben gesagten zu urteilen, giebt es keinen Zweifel über das wirkliche Vorhandensein der Befruchtung bei dieser Pflanze. Die Endosperm- und Embryobildung gehen nach dem gewohnten Modus vor sich.

Kurz hinzufügen wäre noch an dieser Stelle die Beschreibung über meine Kastrationsexperimente an *E. annuus* und *E. linifolius*. Die Köpfchen dieser beiden letzteren wurden an einem passenden Entwicklungsstadium kastriert, so dass nur die Fruchtknoten zurückgeblieben waren. Trotzdem erzeugten die Köpfchen von *E. annuus* die reifen Samen reichlich, während die von *E. linifolius* nach dieser Behandlung alsbald zu Grunde gingen. Die Samen aus den kastrierten Köpfchen von *E. annuus* gelangten im letzten Herbst zur Aussaat. Sie keimten normal und kamen schliesslich im Sommer dieses Jahres zur Blüte. So haben die Ergebnisse meiner cytologischen Untersuchung hier eine weitere Bestätigung erfahren.

### 3. GESCHLECHTLICHE EMBRYOSACKENTWICKLUNG BEI

#### *Erigeron dubius*, Makino.

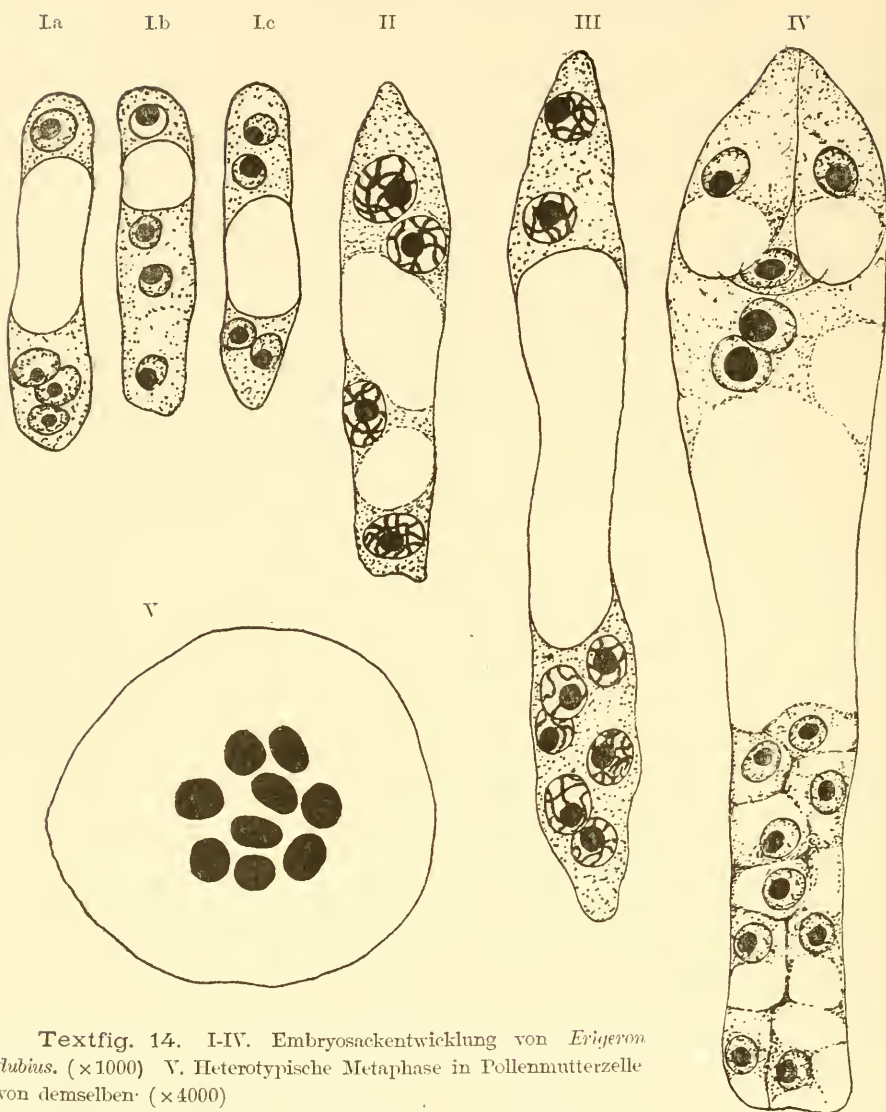
Wie schon erwähnt, hat *E. linifolius* doppelt so viele Chromosomenzahl im Vergleich mit der von *E. annuus*. Dies ist eine bemerkenswerte Erscheinung, weil die bisherigen Untersuchungen über die Pflanzenparthenogenesis in auffällender Weise zeigen, dass die parthenogenetischen Species im Gegensatz zu den normal geschlechtlichen Species derselben Gattung oft durch die grössere Chromosomenzahl sich auszeichnen. Also ist mir das Verhältnis bei *Erigeron* zuerst in nicht geringerem Grade aufgefallen. Die weitere Untersuchung zeigte mir aber, dass alle geschlechtliche Arten von *Erigeron* keine grössere Chromosomenzahl aufzuweisen haben.

*E. dubius*, Makino kann ein Beispiel hierfür geben. Diese Pflanze ist im nordlichen und mittleren Japan ziemlich weit verbreitet; Köpfchen ist viel grösser als die der vorigen zwei Arten. Das Untersuchungsmaterial für diese Pflanze habe ich zuerst selbst in Misaki gesammelt. Im Verlaufe meiner Untersuchung hat es sich aber als ungenügend herausgestellt, um eine endgültige Untersuchung über die Embryosackentwicklung dieser Pflanze auszuführen. So erbat ich Herrn Yamade zu Gotenba schriftlich, einige Exemplare davon mir zu übersenden. Da sandte er mir mit höchster Freundlichkeit sofort eine Anzahl Stöcke von diesem Gewächse zu, wovon ich mir ein ausreichendes Material entnehmen konnte.

Textfig. 14, V. zeigt die heterotypische Kernteilung in den Pollenmutterzellen. Die Zahl der Chromosomen, die bei diesen Teilungen zu Tage treten, beträgt stets nur neun. Also ist sie viel niedriger als die von *E. annuus*. Die meiotischen Kernteilungen in den Embryosackmutterzellen gehen in ähnlicher Weise vor sich. Aber diese Teilungen werden von der Zellteilung nicht begleitet. Also befinden sich in einem Zellraum vier Megasporenkerne. Und diese vier beteiligen sich sämtlich an der Ausbildung des fertigen Embryosackes. In dieser Hinsicht ähnelt die Embryosackentwicklung von *E. dubius* der des *E. annuus*.

Die vier Megasporenkerne liegen zuerst in dem engen Raum der noch kleinen Embryosackanlage unregelmässig kreuzweise oder kettenartig gelagert (Textfig. 14, I a. b. c.). Und nach einem Weilchen teilen sich die vier Kerne gleichzeitig (Textfig. 14, II.). Ein grosser Saft Raum entsteht im Centrum des Embryosackes und teilt die gesamte Plasmamasse in zwei Portionen. Fast für immer befinden sich die zwei Kerne in der oberen Portion und die anderen sechs in der unteren. Inzwischen kommt die letzte, vierte Kern-





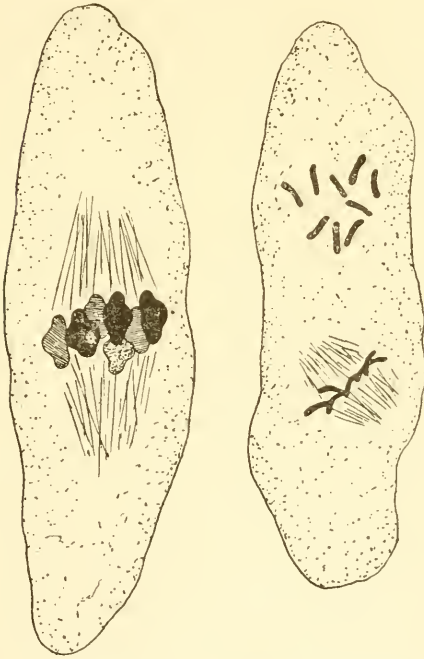
Textfig. 14. I-IV. Embryosackentwicklung von *Erigeron dubius*. ( $\times 1000$ ) V. Heterotypische Metaphase in Pollenmutterzelle von demselben ( $\times 4000$ )

teilung des Embryosackes vor. Allem Anschein nach scheint diese Teilung bei allen oder bei fast allen Kernen übereinsimmd statt zu finden. Textfig. 14, III zeigt ein Stadium, in welchem sich die acht Kerne sämtlich in Prophase der Teilung befinden. Die Zählung der entstandenen Kerne ist aber sehr schwierig, weil in der Samenanlage von dieser Pflanze oft 2 oder 3 Embryosack-



mutterzellen zu liegen pflegen und ausserdem die Kerne von einer Embryosackmutterzelle bzw. Embryosack von den übrigen Kernen von Nucelluszellen schwer zu unterscheiden sind und dieser Umstand beschwert festzustellen, welche Kerne wirklich zu dem Embryosack gehören.

Jedenfalls entstehen eine grosse Anzahl Kerne im Antipodalende (Textfig. 14, IV). Wie bei den normalen, giebt die obere Kernettrade die Anlage zu dem Eiapparat und dem oberen Polkerne. Der untere Polkern stammt aus der antipodalen Kerngruppe ab. Diese beiden Polkerne verschmelzen sich aneinander direkt unter der Eizelle. Aus der Haploidie des Embryosackkerns, welche in Textfig. 15 vergegenwärtigt worden ist, lässt sich das wirkliche Vorkommnis der Befruchtung gar nicht bezweifeln.



Textfig. 15. Hetero- und homöotypische Kernteilung in Embryosackmutterzelle von *Erigeron dubius*. ( $\times 2700$ )

Die Antipoden von *E. linifolius* ist, wie oben erwähnt, auch mehrzellig, wenn es sich auch dabei um eine nachträgliche Vermehrung der Antipodenzellen handelt, welche anfangs in normaler Weise angelegt worden sind. Gegen diese Mehrzelligkeit der Antipodenzellen bei den beiden geschlechtlichen Arten liefert die schwächere Entwicklung von Antipodalapparat bei *E. annuus* einen scharfen Kontrast. Es wäre anzunehmen, dass irgend eine korrelative Beziehung zwischen der Parthenogenese und der Entwicklung des Antipoden existiere.

Neulich schrieb Palm einen

Fall des sechzehnkernigen Embryosackes bei *Chrysanthemum partheniifolium* var. *aureum*. Die Embryosackentwicklung von dieser Pflanze ist fast identisch mit derjenigen von *E. dubius*.

#### IV. Zusammenfassung.

1. Viele Arten von *Chrysanthemum* weisen 18 bzw. 9 Chromosomen bei den Kernteilungen auf. Diese Zahlen müssten also die primäre Chromosomenzahl von dieser Pflanzengruppe sein.

2. Die haploide Chromosomenzahl bei gewissen *Chrysanthemum* Arten weist aber die Multiplen von 9 auf. Nämlich beträgt sie für *Ch. indicum* und *Ch. Leucanthemum* 18, für *Ch. hakusanense* und *Ch. morifolium* 21, für *Ch. Decaisneanum* 36, und für *Ch. marginatum* und *Ch. arcticum* 45.

3. Einige *Chrysanthemum*-Arten beherbergen viele Embryosackmutterzellen in derselben Samenanlage. In diesen Zellen geht die Reduktionsteilung wie normal vor sich.

4. Die Pollenmutterzellen von *Ch. coronarium* sind für die Untersuchung der Reduktionsteilung geeignet. In der frühesten Prophase bilden sich deutlich parallel laufende zarte Fädchen aus. Dieser Parallelismus wird wohl von der Anziehungskraft der homologen Kernelemente herbeigeführt und dauert bis zum Anfang des Knäuelstadiums deutlich. Die wirkliche Längsspaltung des Fadens kommt schon in Spätsynapsis zum Vorschein, gelangt im Knäuelstadium zu ihrem Höhepunkt, wird dann allmählich undeutlich und wird in Diakinesis schwer bemerkbar. Bis zum Knäuelstadium verkleben sich die Chromosomen endweise, um einen langen kontinuierlichen Faden zu bilden. Beim sekundären Synapsisstadium falten sich die Fadenschenkel an einander, drehen sich spiralförmig und dann segmentieren zu den getrennten Chromosomenpaaren. Es scheint mir, als ob *Ch. coronarium* uns einen

interessanten Typus der Rekuktionsteilung darbiete, welche die Faltungstheorie an die Spaltungstheorie überbrücken sollte.

5. Der Typus der Scheidewandbildung bei der Tetradenteilung der Pollenmutterzellen von *Chrysanthemum* gehört nicht zum gewohnten Typus der Dicotyledonen. Nämlich zuerst an vier untereinander tetradisch angeordneten Stellen sieht man kleine Wucherung der Zellwand. Sie wächst allmählich nach dem Centrum der Zelle zu, um dort mit einander zu verschmelzen und schliesslich die Zelle in vier Tochterzellen abzuschneiden.

6. ‚Shasta Daisy‘ ist eine von Luther Burbank durch Kreuzungen unter den verschiedenen Chrysanthemen erzielte Bastardpflanze. Eine von diesen *Chrysanthemum*-Arten soll aus Japan gestammt sein. Aber meiner Meinung nach sollte *C. arcticum* als solche angesehen werden.

Bei der Prophase der heterotypischen Kernteilung in den Pollenmutterzellen tritt die Parallelanordnung des Kernfadens nicht deutlich auf. Dies rührt wahrscheinlich von der schwächeren Anziehungskraft der in dieser Pflanze zusammengebrachten artfremden Kernelmente her. In den heterotypischen Kernplatte zählt man um 85 Chromosomen, wovon einige wenigstens jedoch, nach ihrer Form zu urteilen, als univalent gedacht werden kann. Die Chromosomenzahl in der darauf folgenden homöotypischen Kernteilung beträgt etwa 65. Dann lässt sich der Schluss folgern, dass von 85 Chromosomen in der Kernplatte der heterotypischen Teilung 40 monovalent und 45 bivalent sein können.

7. Den weiteren Beweis dafür, dass die Mutterart von den jetzigen zahlreichen sogenannten japanischen Garten-Chrysanthemen *Ch. morifolium* sei, bringt die Tatsache, dass die vielen japanischen Garten-Chrysanthemen dieselbe Chromosomenzahl mit *C. morifolium* aufzuweisen haben.

8. *Erigeron annuus* ist eine parthenogenetische Pflanze. Ihre Pollenkörner sind ungleichgross. Sie enthalten nur einen Nukleus. Die somatische Kernteilung in den Wurzelspitzen weist 26 Chromosomen auf. Bei der Prophase der ersten Kernteilung der Embryosackmutterzelle kommt die Synapsis vor. Die in der Metaphase von dieser Teilung zum Vorschein kommenden Chromosomen weisen jedoch keine Paarung auf. Also ist die erste Spindel in Embryosackmutterzelle nicht heterotypisch. Gleich nach dieser Teilung folgt die zweite Kernteilung. Aber die Zellwandbildung wird bei diesen beiden Teilungen nie ausgeführt. Die durch diese Teilungen entstandenen vier Kerne beteiligen sich sämtlich an der Ausbildung des Embryosackes. Also wird die einstige Embryosackmutterzelle direkt zur Embryosackanlage, worin jederkern noch eine Kernteilung ausführt. Dabei treten 26 Chromosomen zu Tage. In dem fertigen Embryosacke finden wir, im micropylaren Ende eine Eizelle und zwei Synergiden, und im antipodialen Ende zwei oder drei Kerne, welche in zwei oder drei Zellen umschlossen sind. Unter der Eizelle liegen zwei Polkerne, welche fast für immer eine Menge Cytoplasma zwischen ihnen einschliessen. Die Kernteilung bei Endospermibildung weist 52 Chromosomen auf.

9. *Erigeron linifolius* ist normal-geschlechtlich. Die haploide Chromosomenzahl beträgt 26, doppelt so viel als die der obigen Art. Die Embryosackentwicklung geht bis zum achtkernigen Zustande ganz normal vor sich. Dann kommt eine Anomalie in Antipodalende vor. Zuerst finden wir dort nur zwei Zellen, jedoch später durch die wiedermalige Kern und Zellteilung entsteht eine lange Reihe von den Antipodalzellen, welche je ein, zwei oder mehr Kerne in sich enthalten.

10. *Erigeron dubius* ist auch normal-geschlechtlich. Die Chromo-

somenzahl von dieser Pflanze ist aber sehr niedrig, d. i. 9 in der haploiden Generation. Embryosackentwicklung weist eine interessante Abweichung auf. Die erste und die zweite Kernteilung in der Embryosackmutterzelle geht normal vor sich. Jedoch wird dabei keine Zellwandbildung beobachtet. Die vier Megasporen beteiligen sich sämtlich an der Ausbildung des Embryosackes. Und schliesslich entstehen 16 oder ungefähr so viel Kerne im Embryosack.

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NACHSCHRIFT. Dieses Manuskript war eigentlich schon im Jahre 1917 fertig. Doch aus einigen Gründen hat sich seine Publikation bisher verspätet. Deshalb sind viele seitdem erschienene, recht interessante Arbeiten leider gar nicht berücksichtigt.



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### Tafelerklärung.

Sämtliche Figuren wurden mit Hilfe des Abbéschen Zeichenapparates auf den Tisch in gleicher Höhe mit dem Fusse des Mikroskops entworfen.

#### TAFEL I.

Prophasen der Reduktionsteilung in den Pollenmutterzellen von *Ch. coronarium*. Vergr. 3600 : 1. (Zeiss Apochr. 2 mm., Num. Ap. 1.40 und Komp.—Ok. 18)

Fig. 1. Kern in Ruhestadium.

Fig. 2. Ausbildung der parallel laufenden Kernfäden.

Fig. 3–6. Synapsisstadium.

Fig. 7–8. Spiremstadium.

Fig. 9–11. „Second Contraction.“

Fig. 12. Frühdiakinese.

#### TAFEL II.

Somatische Kernteilung in der Wurzelspitzen von *Ch. coronarium*. Vergr. 3600 : 1. (Zeiss Apochr. 2 mm., Num. Ap. 1.40 und Komp.—Ok. 18)

Fig. 1. Ruhestadium.

Fig. 2–6. Prophase.

Fig. 7–8. Metaphase.

Fig. 9–10. Anaphase.

Fig. 11. Telophase.

#### TAFEL III.

Meiotische Kernteilungen in den Pollenmutterzellen von „Shasta Daisy.“ Vergr. 4000 : 1. (Zeiss 1/12 u. Komp.—Ok. 18)

Fig. 1–2. Synapsis.

Fig. 3. Spirem.

Fig. 4–5. Heterotypische Metaphase.

Fig. 6. Homöotypische Metaphase.

## TAFEL IV.

Pollen- und Embryosack-Entwicklung von *Erigeron annuus*. Vergr. 4000 : 1.  
(Zeiss. 1/12 n. Komp.—Ok. 18)

Fig. 1–7. Meiotische Kernteilungen in den Pollenmutterzellen.

Fig. 8. Mitosis in einer Zelle von Wurzelspitze.

Fig. 9–14. Erste Mitosis im Embryosack.

Fig. 15–17. Endospermnucleus.

Fig. 18–19. Erste Mitosis des Endospermnucleus.

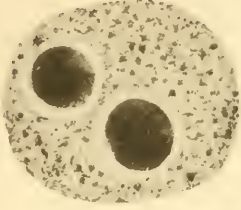
Fig. 20. Mitosis in der späteren Entwicklung von Endosperm.

Fig. 21. 2te. Mitosis im Embryosack.

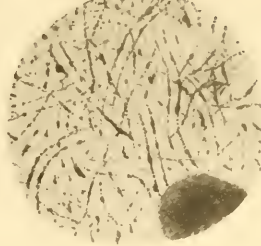




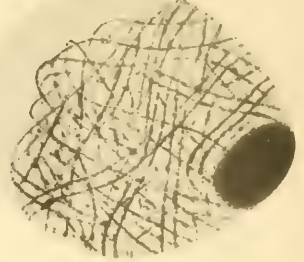
*Fig. 1.*



*Fig. 2.*



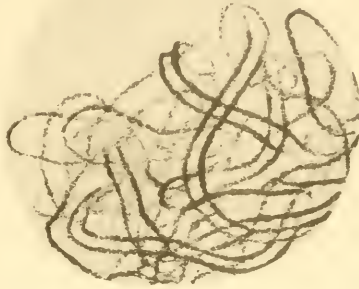
*Fig. 3.*



*Fig. 4.*



*Fig. 5.*



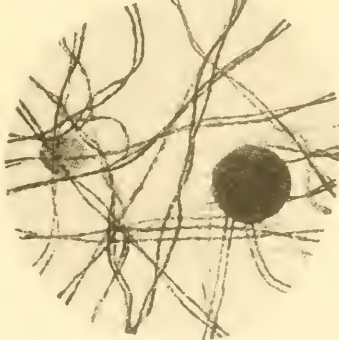
*Fig. 6.*



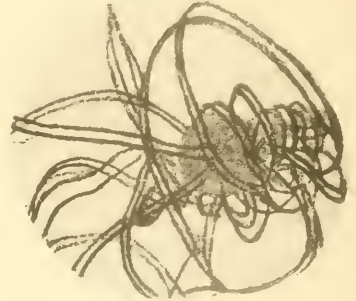
*Fig. 7.*



*Fig. 8.*



*Fig. 9.*



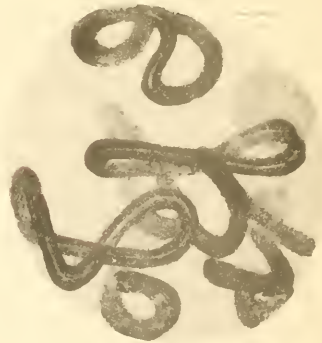
*Fig. 10.*



*Fig. 11.*

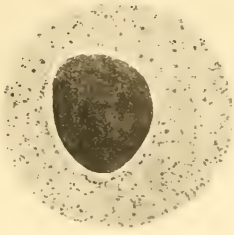


*Fig. 12.*

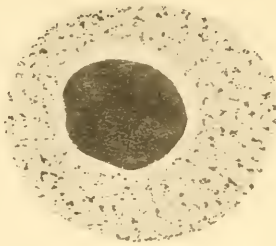




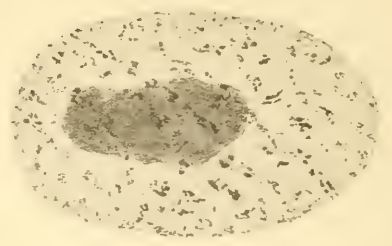
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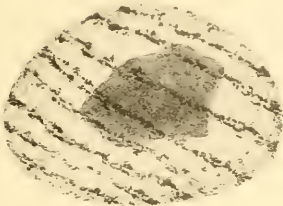
*Fig. 2.*



*Fig. 3.*



*Fig. 4.*



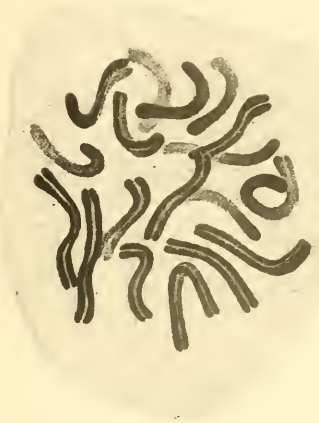
*Fig. 5.*



*Fig. 8.*



*Fig. 7.*



*Fig. 6.*

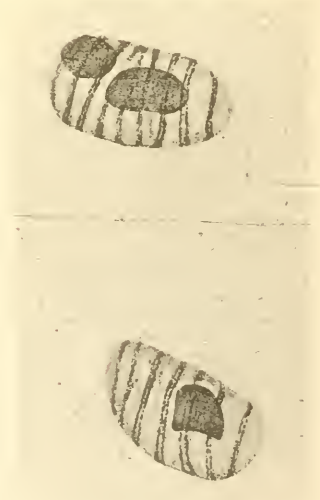


*Fig. 11.*



*Fig. 9.*

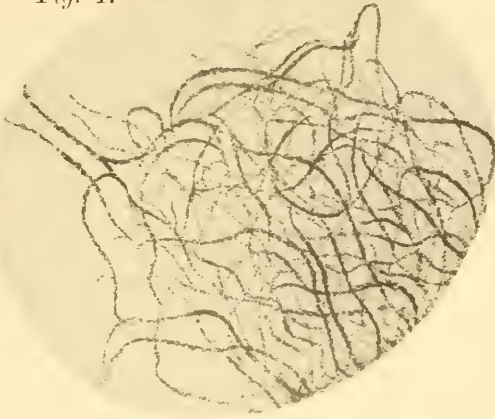
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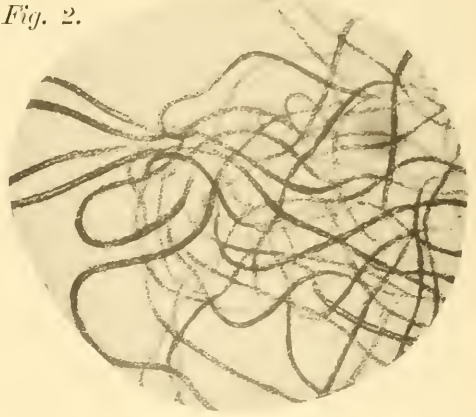




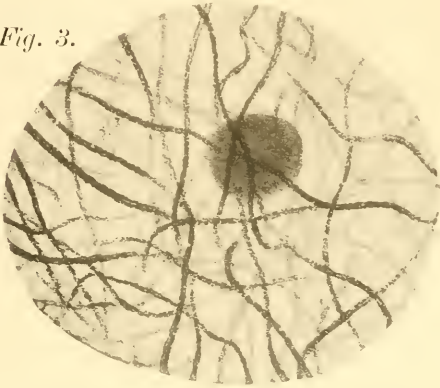
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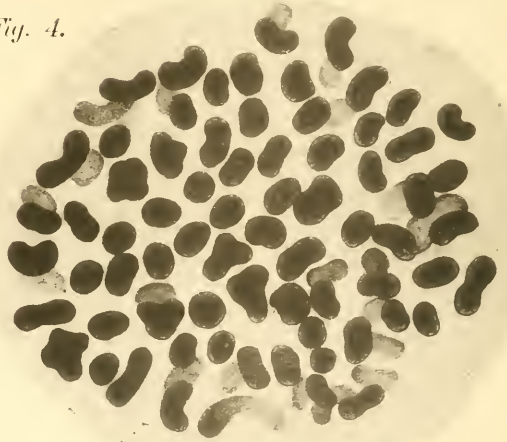
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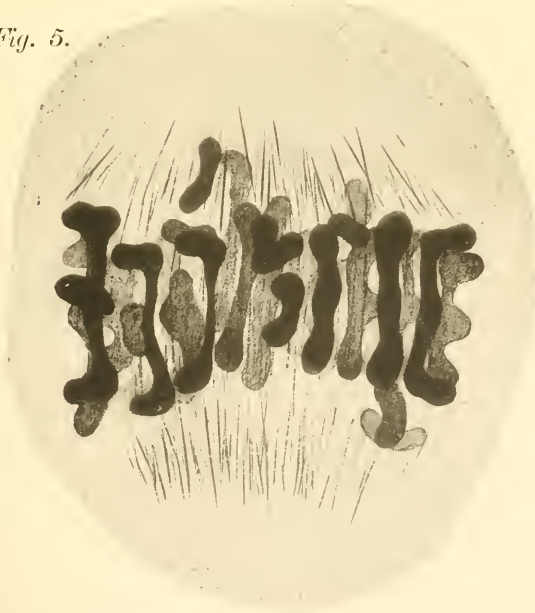
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*Fig. 4.*



*Fig. 5.*



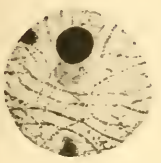
*Fig. 6.*







*Fig. 1.*



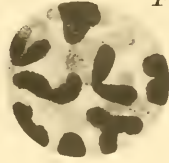
*Fig. 2.*



*Fig. 3.*



*Fig. 4.*



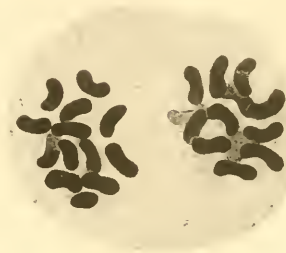
*Fig. 5.*



*Fig. 6.*



*Fig. 7.*



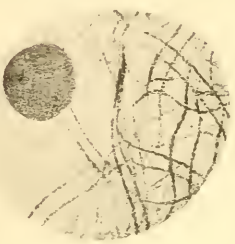
*Fig. 8.*



*Fig. 9.*



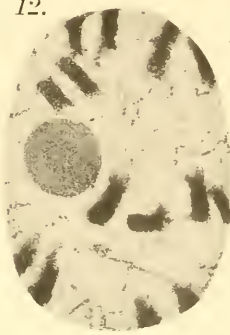
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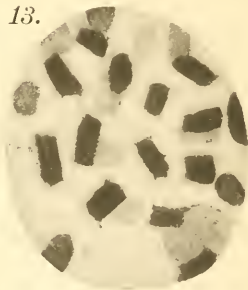
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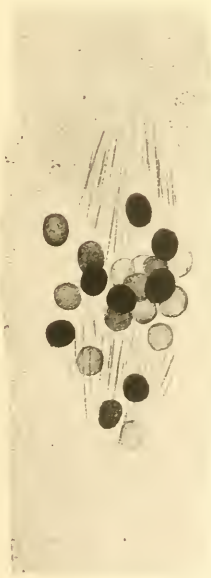
*Fig. 12.*



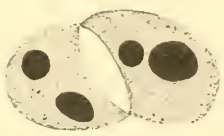
*Fig. 13.*



*Fig. 14.*



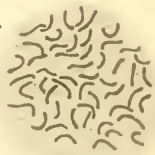
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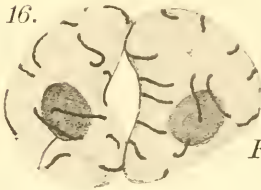
*Fig. 18.*



*Fig. 20.*



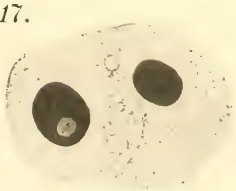
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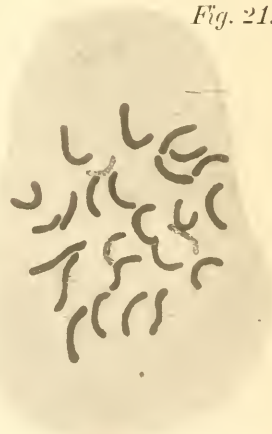
*Fig. 19.*



*Fig. 17.*



*Fig. 21.*





# Enumeratio Labiatarum specierum varietatum formarumque in Insulis Kurilensibus et Insula Yezoensi sponte nascentium.

Auctore

Yûshun Kudô, *Rigakushi*.

## Clavis generum dichotoma.

- 1 { Ovarium breviter vel ad medium 4-lobum .....2.
- 1 { Ovarium ad basin 5-partitum .....3.
- 2 { Corolla bilabiata; labium superius breve, bifidum; inferius elongatum,  
trifidum, lobo medio maximo. Ovarii discus in glandulam tumens ....
- 2 { .....1. *Ajuga* L.
- 2 { Corolla quasi unilabiata; laciniae 4 superiores sæpe subæquales; infima  
maxima, sæpius concava. Ovarii discus æqualis .....2. *Teucrium* L.
- 3 { Calycis labium superius squama dilatata concava instructum .....3. *Scutellaria* L.
- 3 { .....3. *Scutellaria* L.
- 3 { Calyx non squamifer .....4.
- 4 { Stamina 4, in corollæ labio inferiore declinata....21. *Plectranthus* L'Herit.
- 4 { Stamina distantia, erecta vel adscendentia.....5.
- 5 { Antherae biloculares, loculis nec vel vix confluentibus.....6.
- 5 { Antherae loculis confluentibus demum uniloculares.....20.
- 6 { Corollæ labium superius concavum, galeatum .....7.
- 6 { Corollæ lobi omnes plani, patentes .....16.
- 7 { Stamina didynama, superiora longiora .....8.
- 7 { Stamina didynama, inferiora longiora .....11.
- 8 { Antherae loculi subparalleli .....4. *Agastache* Clayt.
- 8 { Antherae loculi divergentes vel divaricati .....9.

- 9 { Calyx apice æqualiter vel subæqualiter 5-dentatus vix bilabiatus ....10.  
 { Calyx distincte bilabiatus .....7. *Dracocephalum* L.
- 10 { Antheræ loculi angulo 180° divaricati. Herbæ erectæ.....5. *Nepeta* L.  
 { Antheræ loculi angulo recto divergentes. Herbæ procumbentes vel repentes  
 .....6. *Glechoma* L.
- 11 { Calyx bilabiatus .....12.  
 { Calyx æqualiter v. subæqualiter 5-dentatus.....13.
- 12 { Corollæ labium superius galeatum. Calyx non inflatus. Filamenta apice  
 bidentata .....8. *Prunella* L.  
 { Corollæ labium superius subconcauum. Calyx demum inflatus. Filamenta  
 edentata .....9. *Chelonopsis* Miq.
- 13 { Antheræ loculi per anthesin dorso-oppositi, transversim 2-valvati.....  
 .....10. *Galeopsis* L.  
 { Antheræ loculi paralleli vel divergentes .....14.
- 14 { Caryopses apice obtusæ nec truncatæ .....13. *Stachys* L.  
 { Caryopses triquetrae apice truncatæ .....15.
- 15 { Corollæ faux dilatata. Calycis dentes non spinosi .....11. *Lamium* L.  
 { Corollæ faux vix dilatata. Calycis dentes spinosi .....12. *Leonurus* L.
- 16 { Stamina basi adscendentia et apice divergentia, per paria conniventia.  
 Calyx 13-nervius .....14. *Satureia* L.  
 { Stamina distantia nec conniventia. Calyx 10-5-nervius .....17.
- 17 { Stamina fertilia 4 .....18.  
 { Stamina fertilia 2 .....19.
- 18 { Stamina didynama. Corolla bilabiata.....15. *Thymus* L.  
 { Stamina subæqualia. Corolla actinomorpha .....17. *Mentha* L.
- 19 { Corolla subæqualis. Stamina distantia nec conniventia. Calyx 5-nervius  
 .....16. *Lycopus* L.  
 { Corolla bilabiata. Stamina sub labio superiore conniventia. Calyx 10-  
 nervius .....18. *Mosla* Hamilt.
- 20 { Corolla breviter 4-fida. Calyx æqualiter 5-dentatus. Ovarii discus inæqualis  
 glandulosus .....19. *Elsholtzia* Willd.  
 { Corolla 5-loba, bilabiata. Calyx bilabiatus. Ovarii discus æqualis,  
 eglandulosus .....20. *Comanthosphace* Moore.

1. *Ajuga* L.

## CLAVIS SPECIERUM ET FORMARUM DICHOTOMA.

- |   |   |   |  |
|---|---|---|--|
| 1 | { | Verticillastri axillares omnes remoti. Corollae pallide coeruleae. Caulis decumbens . . . . . | 2.   |
|   |   | Verticillastri caulis apice spicati. Corollae intense coeruleae. Caulis erectus . . . . .     | <i>A. ciliata</i> Bge., f. <i>Chaneti</i> Kudo.      |
| 2 | { | Folia caulina late ovalia vel fere rotundata . . . . .  |  |
|   |   | Folia caulina elliptico-spathulata, oblongo-elliptica vel elliptica . . . . .                 | <i>A. yezoensis</i> Maxim., f. <i>typica</i> Kudo.   |
|   |   |   | <i>A. yezoensis</i> Maxim., f. <i>elongata</i> Kudo. |

1. *Ajuga yezoensis* Maxim. apud Fr. et Sav. Enum. Fl. Jap. II. (1879) p. 467, et Mém. Biol. XI. (1883) p. 811; Nakai, Bot. Mag. Tokyo, XXV. (1911) p. 151; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 537; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 295; Kudo, Rep. Vegt. Nopporo Forest (1917) p. 26.

forma **typica** Kudo. (Tab. I, fig. 1.).

Folia caulina late ovalia vel fere rotundata, breviter vel longius petiolata.

NOM. JAP. *Nishikigoromo*, *Kiumonsō*.

HAB. *Hokkaido*. Prov. Oshima: Yunokawa (F. C. Greatrex! Maio 1916); Ichinowatari (Miyabe et Tokubuchi! Julio 1890); Komagatake (Y. Odagiri! Julio 1890).—Prov. Shiribeshi; Shiribetsu (T. Ishikawa!).—Prov. Iburi: Shikifu (Y. Odagiri! Maio 1894); Horobetsu (Y. Odagiri! Junio 1890).—Prov. Hidaka: Saruru-Sando (Miyabe! Junio 1884); Samani-Sando (K. Kondo! Aug. 1912).—Prov. Ishikari: Maruyama (Y. Kudo! n. 2756, Junio 1917); in silvis Nopporo (Y. Kudo! n. 1321, Junio 1915); Nishino (Y. Kudo! n. 4352, Maio 1918); monte Moiwa (T. Mimatsu! Oct. 1910; Y. Kudo! n. 1426, Maio 1916); Hassabu (H. Yanagisawa! Maio



1912; M. Takenouchi! Junio 1917); Sankakuyama (J. Iwasaki! Maio 1912); Sapporo (Class'80! Junio 1878); Tsukisappu (K. Miyabe! Junio 1884); Sorachibuto (K. Miyabe! Aug. 1891).

DISTRIB. Hokkaido, Honshu et Shikoku.

forma **elongata** Kudo.

Folia caulina elliptico-spathulata, oblongo-elliptica, elliptica, sæpius longe petiolata. Cetera formæ typicæ.

NOM. JAP. *Nagaha-nishikigoromo* (nov.).

HAB. *Hokkaido* Prov. Shiribeshi: ins. Okushiri: (Miyabe et Tokubuchi! Julio 1890).—Prov. Ishikari: (K. Miyabe! Aug. 1891).

DISTRIB. Forma endemica!

Primo aspectu specimina magna *Ajugæ decumbentis* simulat. Sed labio superiore protracto, nuculis laxè reticulatis ab ea distincta. A simili *Ajuga bastarda* Makino (= *Ajuga decumbens* × *Ajuga yezoensis* Makino, Bot. Mag. Tokyo, XXVI. [1912] p. 175.), quacum folium convenit, distincta verticillastris multifloris, floribus pallide cœruleis, etc.

2. **Ajuga ciliata** Bunge\* Enum. Pl. China Bor. (1835) p. 51; Benth. in DC. Prodr. XII. (1848) p. 596; A. Gray, Bot. Jap. (1858) p. 402; Maxim. Ind. Fl. Pek. in Prim. Fl. Amur. (1859) p. 476, et Mém. Biol. XI. (1883) p. 814; Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 314; Diels, Fl. Centr. China, in Engl. Bot. Jahrb. XXIX. (1901) p. 550.

form. c. **Chaneti** (Lév'l. et Vnt.) Kudo. (Tab. I, fig. 2.).

*Ajuga Chaneti* Lév'l. et Vnt., in Fedde, Repert. VIII. (1910) p. 258.

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\* **Ajuga ciliata** Bunge, form. a. **typica** Kudo. Caulis glaber. Folia glabriuscula, margine ciliata. Flores cœrulei. Hab. in China boreali.—**Ajuga ciliata** Bunge, form. b. **glabrescens** (Hemsl.) Kudo. = *Ajuga ciliata* Bunge, var. *glabrescens* Hemsl. in Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 315; Diels, Fl. Centr. China (1901) p. 550. = *Ajuga ciliata* Dunn, Lab. China, in Notes Roy. Bot. Gard. Edinbg. VI. Num. XXVIII. (1915) p. 194 (non Bunge). Flores albi. Cetera formæ typicæ. Hab. in China.



*Ajuga orientalis* Thunb. Fl. Jap. (1784) p. 243 ; A. Gray, Bot. Jap. (1858) p. 402, (non L.).

*Ajuga genevensis* Miq. Prol. Fl. Jap. (1866-67) p. 46 ; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 382 ; Forb. et Hemsl. Ind. Fl. Sin. II. p. 315, (p. p.) non L.

*Ajuga ciliata* Fr. et Sav. Enum. Pl. Jap. II. (1897) p. 465 ; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 535 ; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 295, (non Bge.).

Caulis in quaque facie hirsutus. Folia villosa. Flores sæpe cœrulei.

NOM. JAP. *Kai-jindo*.

HAB. *Hokkaido*. Prov. Oshima : Hakodate (F. C. Greatrex ! Junio 1916 ; S. Nozawa ! Julio 1886) ; Esashi (Miyabe et Tokubuchi ! Aug. 1890).—Prov. Hidaka : Pankeushapu, Saru (C. Yendo ! Julio 1895) ; prope Okoshi (Y. Tokubuchi ! Aug. 1892) ; Niikappu (K. Miyabe ! Junio 1884).—Prov. Ishikari : Tsukisappu (Y. Kudo ! n. 4353, Junio 1918) ; Garugawa (Y. Kudo ! n. 4354, Junio, 1918 ; M. Takenouchi ! Junio 1917) ; monte Teine (M. Takenouchi ! Junio 1917) ; Maruyama (J. Iwasaki ! Junio 1913) ; Sapporo (Takenobu ! Junio 1882) ; Omagari, Tsukisappu (Y. Tokubuchi ! Junio 1894).—Prov. Kitami : Furetoi (Y. Kudo ! n. 3461, Julio 1917).

DISTRIB. formæ. *Hokkaido*, *Honshu*, et in *China* centrali.

## 2. *Teucrium* L.

### CLAVIS SPECIERUM DICHOTOMA.

- |   |   |  |                               |
|---|---|--|-------------------------------|
| 1 | { | Verticillastri 2-flori. (Sect. <i>Scorodonia</i> Benth) . . . . .    | 2.                            |
|   |   | Verticillastri spicati. (Sect. <i>Stachyobotrys</i> Benth) . . . . . | 3.                            |
| 2 | { | Calyx glandulosus. Nuculæ subleves . . . . .                         | <i>T. veronicoides</i> Maxim. |
|   |   | Calyx glaber. Nuculæ reticulato-rugosæ . . . . .                     | <i>T. teinense</i> Kudo.      |

- 3 { Calyx pubescens, eglandulosus. Racemus compositus, pyramidalis .....  
 ..... *T. japonicum* Willd.  
 Calyx glanduloso-pubescens. Racemus simplex, subsecundus .....  
 ..... *T. Miquelianum* Kudo.

3. **Teucrium veronicoides** Maxim. (Tab. I, fig. 3.) Mél. Biol. IX. (1876) p. 826, et Bull. Acad. Petersb. XXIII. (1877) p. 388; Fr. et Sav. Enum. Pl. Jap. II. (1879) p. 465; Briq. Labiat. in Engl. u. Prantl, Nat. Pfl.-fam. IV. 3. a. (1897) p. 213; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 522; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 295.

*Teucrium nipponicum* Makino, in Schid. Herb. Coll. Sc. Imp. Univ. Tokyo.

NOM. JAP. *Yezo-nigakusa*.

HAB. *Hokkaido*. Prov. Oshima: in loco Cryptomeriis composito, prope Kamiiso (F. C. Greatrex! Oct. 1917).—Prov. Ishikari: Kamiteine (M. Takenouchi! Sept. 21, 1917); Sapporo (Class'80! Aug. 1878; K. Miyabe! Aug. 1880); Sunakawa (K. Miyabe! Aug. 1891); Umon, Kamikawa (K. Miyabe! Aug. 1891).

DISTRIB. *Hokkaido* et *Honshu*.

Species ad sectionem *Stachyobotrycem* Benth. a Briquet referenda, sed racemis foliatis, verticillastris remotis bifloris, ad sectionem *Scorodoniam* referre esse videtur.

4. **Teucrium teinense** Kudo, sp. nov. (Tab. I, fig. 4.).

Caulis erectus vel ascendens, 28 cm altus, glaber, ad nodos longe parceque pilosus. Folia anguste ovata vel oblongo-ovata, apice acuminata, basi cuneata, supra longe pilosa, subtus glabra vel parce pilosa, margine inæqualiter subduplicato-inciso-serrata, 3.—4.8 cm longa, 1.4—2.1 cm lata, petiolis lamina brevioribus, 1.3—1.8 cm longis. Flores axillis foliorum solitaires, pedunculis calycibus subæquilongis. Calyx 3.5—4 mm longus, glaber vel sub-

glaber, dentibus 3 superioribus inæqualibus, deltoideis, acuminatis, 2 infimis deltoideis, acutis. Corolla 7–8 mm longa, tubo e calyce non exserto, labio tubo longiore, lobis lateralibus superioribus oblongo-ovatis, acutiusculis, sequentibus duobus deltoideis, acuminatis, lobo terminali ovale, multo majore. Nuculæ mihi ignotæ.

NOM. JAP. *Teine-nigakusa*.

HAB. *Hokkaido*. Prov. Ishikari: Garugawa (Y. Kudo! n. 4126, Julio 1914; K. Miyabe! Julio 1891); Sapporo (K. Miyabe! Julio 1880).

DISTRIB. Endemica!

Species omnino sui juris tantum cum *Lycopo Miqueliano* comparanda, sed diversissima, habitu potius *Nepetæ* quibusdam accedans.

5. ***Teucrium japonicum*** Willd. (Tab. I, fig. 5.) Spec. P. III. p. 23; Benth. in DC. Prodr. XII. (1848) p. 581; Miq. Ann. Mus. Bot. Lugd. Bat. II. p. 113 et Prol. Fl. Jap. p. 45 (1866–67); Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 381; Maxim. Mém. Biol. IX. (1876) p. 824, et XI. (1883) p. 808; Forb. et Hemsl. Ind. Fl. Sin. II. (1888–1902) p. 312; Briq. Labiat. in Engl. u. Prantl. Nat. Pfl.-fam. IV. 3. a. (1897) p. 213; Diels, Fl. Centr. China, in Engl. Bot. Jahrb. XXIX. (1901) p. 551; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 552; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 295; Dunn, Labiat. China, in Notes Roy. Bot. Gard. Edinbg. Vol. VI. Numb. XXVIII. (1915) p. 191.

*Teucrium virginicum* Thunb. Fl. Jap. (1784) p. 244 (non L.).

*Teucrium nepetoides* Lévl. in Fedde, Repr. VIII. (1910) p. 450.

NOM. JAP. *Nigakusa*.

HAB. *Hokkaido*. Prov. Oshima: Hakodate (Maximowicz, Aug. 1861; F. C. Greatrex! Sept. 1916).

DISTRIB. *Hokkaido*, *Honshu*, *Shikoku* et *China*.

forma **hispidovillosus** Kudo.

Calyx hispido-villosus. Cetera typi.

HAB. *Hokkaido*. Prov. Ishikari: Sapporo (Class'80! Aug. 1878).

DISTRIB. Endemica!

6. ***Teucrium Miquelianum*** (Maxim.) Kudo. (Tab. I, fig. 6.).

*Teucrium stoloniferum* Hamilt.,  $\beta$ . *Miquelianum* Maxim. Mél. Biol. IX. (1876) p. 826; Fr. et Sav. Enum. Pl. Jap. II. (1879) p. 465; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 552; Matsum. et Kudo, Bot. Mag. Tokyo XXVI. (1912) p. 296; Kudo et Yoshimi, Report. Veg. Tomakomai Forest (1916) p. 52; Kudo, Report. Veg. Nopporo Forest. (1917) p. 26.

*Teucrium stoloniferum* Miq. Prol. Fl. Jap. (1866-67) p. 45; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 381, (non Hamilt.).

NOM. JAP. *Tsuru-nigakusa*.

HAB. *Hokkaido*. Prov. Oshima: Hakodate (F. C. Greatrex! Aug. 1916).—Prov. Iburi: in silvis Tomakomai (Y. Kudo! n. 4892, Oct. 1919; T. Yoshimi! Julio 1914); Kuttara (S. Yenomoto! Aug. 1914). Oiwake (Y. Tokubuchi! Aug. 1894).—Prov. Hidaka: Saruru (Y. Tokubuchi! Aug. 1892).—Prov. Ishikari: Moiwa (Y. Kudo! n. 4768, Aug. 1919); in silvis Nopporo (Y. Kudo! n. 1332, Sept. 1915); Garugawa (M. Takenouchi! Julio 1917); in monte Teine. ad Munatsuki 8 cho (H. Yanagisawa! Sept. 1915); Makomanai (K. Miyabe! Sept. 1883); Sorachibuto, Sorachi (K. Miyabe! Aug. 1891); Kamuikotan (K. Miyabe! Aug. 1891); Sunakawa (K. Miyabe! Aug. 1891).—Prov. Kitami: ins. Rebun (K. Miyabe! Aug. 1894); in ins. Rebun, prope Kafuka (Y. Kudo! n. 1791, Julio 1915).

DISTRIB. *Hokkaido*, *Honshu* et *Kiushu*.

Species intermedia inter *Teucrium japonicum* Maxim. et *Teucrium*

*stoloniferum* Roxb.\* Prima specie differt floribus minoribus, calycibus pilosis, racemis simplicis nec compositis. Posteriore specie longe differt foliorum et florum forma, statura etc.

### 3. *Scutellaria* L.

- |   |   |   |                             |
|---|---|---|-----------------------------|
| 1 | { | Racemi terminales . . . . .   | <i>S. ussuriensis</i> Kudo. |
|   | { | Racemi vel flores axillares . . . . .   | 2.                          |
| 2 | { | Flores parvi, ca. 6 mm longi . . . . .  | <i>S. dependens</i> Maxim.  |
|   | { | Flores majores, ca. 2 cm longi . . . . .  | 3.                          |
| 3 | { | Folia oblongo-lanceolata, ovato-lanceolata, sursum saepe acuminata, utrinque subglabra vel crispulo-pubescentia. Flores intense violaceo-caerulei . . . . . | <i>S. yezoensis</i> Kudo.   |
|   | { | Folia oblonga vel lineari-oblonga, apice obtusa vel mucronata, utrinque adpresse hirsuta. Flores pallide caerulei vel caerulei . . . . .                    | <i>S. Schmidtii</i> Kudo.   |

7. *Scutellaria ussuriensis* Kudo, (Tab. I. fig. 7.) in Kudo et Yoshimi, Report Veg. Tomakomai Forest (1916) p. 53 et Report Veg. Nopporo-Forest (1917) p. 26.

*Scutellaria japonica* Maxim. Prim. Fl. Amur. (1859) p. 218, (non Morr. et Decne.).

*Scutellaria japonica* Morr. et Decne., *β. ussuriensis* Rgl. Tent. Fl. Ussuri (1862) p. 118, n. 389; Nakai, Fl. Korea. II. (1911) p. 144.

*Scutellaria nipponica* Makino, Bot. Mag. Tokyo, VI. (1892) p. 54, (non Fr. et Sav.).

*Scutellaria transitra* Makino, Bot. Mag. Tokyo, XVIII. (1904) p. 70.

*Scutellaria indica* L., var. *ussuriensis* Kom. Fl. Mansh. III. (1907) p. 340.

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\* *Teucrium stoloniferum* Roxb. Fl. Ind. III. (1824) p. 3; Benth. in DC. Prodr. XII. (1848) p. 583, et Fl. Hongk. (1862-72) p. 279; Maxim. Mém. Biol. IX. (1876) p. 825 (excl. *β.*); Hook. f. Fl. Brit. Ind. II. (1879) p. 700; Forb. et Hemsl. Ind. Fl. Sin. II. (1883-1902) p. 314; Diels, Fl. Centr. China, in Engl. Bot. Jahrb. XXIX. (1901) p. 551.



*Scutellaria dentata* Lév'l. in Fedde, Repert. IX. (1911) p. 246.  
 NOM. JAP. *Yezo-tatsunamisō* (nov.).

HAB. *Hokkaido*. PROV. Oshima: Hakodate (Miyabe et Tokubuchi! Julio 1890; F. C. Greatrex! Junio 1916); Ōnuma (F. C. Greatrex! Oct. 1915); Fukuyama (Miyabe et Tokubuchi! Julio 1890).—Prov. Shiribeshi: ins Okushiri (Miyabe et Tokubuchi! Julio 1890); Kudo (Miyabe et Tokubuchi! Julio 1890); Raiden-toge (Y. Tokubuchi! Julio 1888; T. Ishikawa! Julio 1897).—Prov. Iburi: in silvis Tomakomai (Y. Kudo! n. 928, Junio 1915; n. 4823, Oct. 1919; T. Yoshimi! Julio 1914); Yakumo (Y. Odagiri! Julio 1894); Oiwake (Y. Tokubuchi! Aug. 1893); Usu (S. Hashimoto! Junio 1890).—Prov. Hidaka: Saruru (Y. Tokubuchi! Aug. 1892).—Prov. Ishikari: Maruyama (Y. Kudo! n. 4360, Junio 1916); in monte Teine (Y. Kudo! n. 278, Junio 1914 et n. 4361, Julio 1918; H. Yanagisawa! Julio et Sept. 1915); in silvis Nopporo (Y. Kudo! n. 1331; Sept. 1915); Hassabu (J. Iwasaki! Julio 1912; H. Yanagisawa! Sept. 1913); Sapporo (Class'80! Julio 1878); Iwamizawa (S. Tamaki! Julio 1914); Otoibokke (K. Miyabe! Aug. 1891); Kamuikotan (K. Miyabe! Aug. 1891); in monte Taisetsu (H. Koidzumi! Julio 1910); Manju (F. C. Greatrex! Aug. 1915); Kamikawa (H. Koidzumi! Julio 1911).—Prov. Teshio: in silvis Teshio (Y. Kudo! n. 4576, Julio 1919).—Prov. Tokachi: ad fl. Tomuraushu (S. Nishida! Julio 1914).—Prov. Kushiro: Setsuri (Sukeo Ito! Julio 1895); Beppo (Tanaka et Miyabe f.! Julio 1910); Kushiro (K. Miyabe! Aug. 1884).—Prov. Nemuro: Nemuro (M. Nakamura! Julio 1884).—Prov. Kitami: Sanrubeshibe ad fl. Nayero (S. Yokoyama! Julio 1892); ins Rishiri (S. Hori! Aug. 1887; Y. Kudo! n. 2058, Julio 1916); ins. Rebun inter Rebundake et Obashitomanai (Y. Kudo! n. 1790, Julio 1916).

DISTRIB. *Hokkaido*, *Honshu*, *Korea*, *Manchuria* et *Ussuri*.



8. **Scutellaria dependens** Maxim. (Tab. I, fig. 8.) Prim. Fl. Amur. (1859) p. 219; Rgl. Tent. Fl. Ussuri (1862) p. 119; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 377; Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 294; Korsh. Pl. Amur. (1892) p. 378; Palib. Consp. Fl. Korea. II. (1899–1901) p. 28; Kom. Fl. Mansh. III. (1907) p. 341; Nakai, Fl. Korea. II. (1911) p. 143; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 550; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 296; Kudo et Yoshimi, Report. Veg. Tomakomai Forest (1916) p. 53; Kudo, Report. Veg. Nopporo Forest (1917). p. 26.

*Scutellaria Oldhami* Miq. Ann. Mus. Lugd.-Bat. III. p. 197 et Prol. Fl. Jap. p. 361 (1866–67), fide Maximowicz.

*Scutellaria nipponica* Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 337.  
NOM. JAP. *Hime-namiki*.

HAB. *Hokkaido*. Prov. Oshima: Fukuyama (T. Kawakami! Aug. 1892); Ōnuma (Y. Tokubuchi! Aug. 1888).—Prov. Iburi: Chitose (K. Miyabe! Aug. 1890); Oiwake (Y. Tokubuchi! Aug. 1893); Numanohata (J. Hanzawa! Aug. 1899); in silvis Tomakomai (T. Yoshimi! Aug. 1914).—Prov. Ishikari: in silvis Nopporo (Y. Kudo! n. 1330, Sept. 1915); Kami-Teine (M. Takenouchi! Julio 1917); Atsubetsu (S. Yenomoto! Julio 1918); Otoibokke (K. Miyabe! Aug. 1891); Poronai (Y. Tokubuchi! Julio 1887); Sapporo (Class'80! Aug. 1878; Y. Tokubuchi! Julio 1894); Sunakawa (K. Miyabe! Aug. 1891).—Prov. Kushiro: Nusamai (M. Nakamura! Sept. 1886).—Prov. Nemuro: in superiore parte ad fl Shibetsu (K. Miyabe! Julio 1884).

DISTRIB. *Hokkaido*, *Honshu*, *Korea*, *Manchuria*, *Amur* et *Ussuri*.

*Scutellaria minor* L.\* affinis, sed differt, caule dependente, foliis obtusissimis, tenuiter membranaceis, floribus remotis.

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\* *Scutellaria minor* L. Spec. Pl. p. 835; Benth. in DC. Prodr. XII. (1848) p. 426; Ledeb. Fl. Ross. III. (1846–51). p. 399; Hook. and Arnot. Brit. Fl. (1835) p. 334.—Hab. in palustribus Asiae mediae et Europae; in India orientali (*β. indica* Benth.).

9. **Scutellaria** (Galericulatæ) **yezoensis** Kudo. sp. nov. (Tab. I, fig. 9.).

*Scutellaria galericulata* Fr. Schm. Fl. Sachal. (1868) p. 165; Kudo, Bot. Mag. Tokyo, XXVIII. (1914) p. (362), (non L.).

*Scutellaria galericulata* L., varr. *angustifolia* et *puberula* Matsum. Ind. Pl. Jap. II. 2. (1912) p. 550, (non Rgl.).

? *Scutellaria scordifolia* Fisch., form. *puberula* Takeda, Bot. Mag. Tokyo, XXIV. (1910) p. 315 et Fl. Shikotan (1914) p. 315, (excl. syn. non Kom.)

*Scutellaria scordifolia* Fisch., var. *puberula* Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 296.

*Scutellaria galericulata* L.,  $\beta$ . *pubescens* Nakai, Bot. Mag. Tokyo, XXVIII. (1914) p. (167); Miyabe and Miyake, Fl. Saghal. (1915) p. 366 (non Rgl.).

*Scutellaria scordifolia* Fisch., var. *puberula* Nakai, Bot. Mag. Tokyo, XXVIII. (1914) p. (168), (non Kom.).

Caulis erectus, simplex vel ramosus, 35–70 cm altus, ad angulos parce crispulo-pubescens. Folia breviter petiolata, oblongo-lanceolata, ovato-lanceolata, vel elongato-ovata, apice acuminata vel acuta, basi truncata vel breviter cordata, margine crenato-dentata, supra sæpe crispulo-puberulentia vel subglabriuscula et subscabro-punctata, subtus pallidiora, densiuscule crispulo-pubescentia, 2.5–5.5 cm longa, 1—2 cm lata, petiolis inferioribus sæpe 4 mm longis, sensim sursum abbreviatis; floralia oblongo-lanceolata, apice acuminata, basi subcordata, brevissime petiolata, margine obscure crenulato-dentata vel subintegra, plus-minus minora, ceteris notis foliis caulinis similia. Flores axillares, remoti, oppositi, pedunculis calyce florifero  $1/3$  longioribus. Calyx campanulatus, 4–5 mm longus, albo-crispulo-pubescens. Corolla intense violaceo-cœrulea, extus crispulo-pubescens, 2–2.4 cm longa. Nuculæ ellipticæ, dense tuberculatæ,

1.5–1.8 mm longæ.

NOM. JAP. *Yezo-namiki*, *Ōnamiki*.

HAB. *Hokkaido*. Prov. Iburi; Wanishi (Y. Kudo! n. 4027, Aug. 1916); Shiraoi (S. Tamaki! Julio 1914); Yūbutsu (J. Hanzawa! Aug. 1899); Tomakomai (J. Hanzawa! Aug. 1899).—Prov. Hidaka: Mitsuishi (Y. Kudo! n. 627, Aug. 1914); Urakawa (Y. Kudo! n. 623, Aug. 1914).—Prov. Ishikari: Horomui (Y. Kudo! n. 2163, Julio 1916; n. 4787, Aug. 1919; S. Tamaki! Julio 1914; Y. Tokubuchi! Julio 1887); Garugawa (Y. Odagiri! Julio 1893); Okadamura (K. Miyabe! Sept. 1893; Y. Tokubuchi! Julio 1894); Sapporo (Takenobu! Julio 1882; Y. Tokubuchi! Aug. 1887); Sorachi (Jūro Kawakami! 1890); Maoi (Y. Odagiri! Julio 1893); Shibunbetsu (K. Tsutsuki! Aug. 1918).—Prov. Teshio: Totomanai (S. Ninoue! Sept. 1905); Kokuneppu (S. Ninoue! Aug. 1905).—Prov. Kushiro: Kushiro (I. Muto! Julio 1917); Shiranuka (K. Miyabe! Aug. 1884); Nusamai (M. Nakamura! Aug. 1886).—Prov. Kitami: Abashiri (T. Yagihashi! Aug. 1910); Bekkai (K. Miyabe! Aug. 1894).

*Chishima*. Ins. Kunashiri: ad lacum Biroku, prope Ruyabetsu (C. Yendo! Aug. 1894).—Ins. Shikotan: Anama (M. Arai! Aug. 1909).—Ins. Etorofu: Naibo (T. Kawakami! Sept. 1898); Shana (S. Fujimura! Aug. 1890).

DISTRIB. In insulis Sachalin, Kurilensibus, Hokkaido et in Honshu boreali.

Species *Scutellarice galericulatæ* affinis, sed statim dignoscenda, caule elato, foliis minus crassis, floribus majoribus, seminibus etiam majoribus etc.

10. **Scutellaria** (*Galericulatæ*) **Schmidtii** Kudo. (Tab. I, fig. 10.).

*Scutellaria scordifolia* Fisch., var *hirta* Fr. Schm. Fl. Sachal. (1868) p. 165; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 296.

*Scutellaria scordifolia* Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 377, (p.p. non Fisch.).

*Scutellaria galericulata* L., var. *scordifolia* Herder, P. Radd. in Act. Hort. Petrop. X. I. p. 88 (1885) (non Rgl. quoad Pl. Hakodate); Miyabe, Fl. Kuril. (1890) p. 255.

*Scutellaria galericulata* L., form. *pubescens* Takeda, Bot. Mag. Tokyo, XXIV. (1910) p. 315 et Fl. Shikotan (1914) p. 482 (non Kom. excl. syn. nonnull.).

*Scutellaria galericulata* L., form. *hirta* Koidzumi, Pl. Sachal. Nakah. (1910) p. 104.

*Scutellaria scordifolia* Fisch., var. *pubescens* Nakai, Bot. Mag. Tokyo, XXVIII. (1914) p. 168, (p.p. non Miq.).

*Scutellaria galericulata* L., var. *pubescens* Matsum. Ind. Pl. Jap. II. 2. (1912) p. 550, (non Rgl.).

Caulis erectus, procumbens, repens, sæpius ramosus, semper dense albo-hirsutus, 8–45 cm altus. Folia breviter petiolata, oblonga vel lineari-oblonga, apice obtusa, mucronata, rotundata, basi truncata, leviter hastato-cordata, margine crenulato-serrata, untrinque facie adpresse hirsuta, 1.3–3.4 cm longa, .7–1.6 cm lata, petiolis brevissimis 2 mm longis, sursum sensin abbreviatis; floralia sæpe conformia, tamen minora. Flores axillares oppositi, pedunculis rectis vel curvatis, dense albo-pubescentibus. Calyx campanulatus, ca. 3 mm longus, dense albo-pubescentibus. Corolla cœrulea, extus hirtella, 2.–2.3 cm longa, ca. 1 mm lata. Nuculæ ellipticæ dense tuberculatæ, ca. 1.8 mm longæ.

NOM. JAP. *Hama-namikisō*.

HAB. *Hokkaido* Prov. Oshima: inter Fukuyama et Yoshioka (Y. Kudo! n. 3799, Aug. 1917); prope Fukuyama, (Y. Kudo! n. 3799, Aug. 1917); Fukuyama, Tate-ishino (Y. Kudo! n. 3798, Aug. 1917); Hakodate (S. Nozawa! Julio 1886; F. C. Greatrex!

Oct. 1915); Kamiiso (Miyabe et Tokubuchi! Julio 1890); in insl. Kamome (Miyabe et Tokubuchi! Julio 1890).—Prov. Shiribeshi: ins. Okushiri (Miyabe et Tokubuchi! Julio 1890); inter Poronai et Aonai (Y. Kudo! n. 2521, Aug. 1916); inter Aonai et Tsurikake (Y. Kudo! n. 2568, Aug. 1916); Oshoro (Y. Tokubuchi! Julio 1888); Yoichi, Bugoppe (I. Yamomoto! Oct. 1914).—Prov. Iburi: Muroran (Y. Kudo! n. 4028 et 4029, Aug. 1917); Nishitappu (Y. Kudo! n. 375, Julio 1914); Shiraoi (S. Tamaki! Julio 1914); Tomakomai (S. Tamaki! Julio 1914; J. Hanzawa! Aug. 1899); Numanohata (J. Hanzawa! Aug. 1899); Mombetsu (S. Hashimoto! 1890).—Prov. Hidaka: inter Motoura et Urakawa (Y. Kudo! n. 622, Aug. 1914); Shoya (Y. Kudo! n. 621, Aug. 1914); Saruru (Y. Tokubuchi! Aug. 1892); Okoshi (Y. Tokubuchi! Aug. 1892); Horoidzumi (Y. Tokubuchi! Aug. 1892).—Prov. Ishikari: Garugawa (J. Iwasaki! Sept. 1912; M. Takenobu! Julio 1917).—Prov. Teshio: Wienbetsu (T. Ishikawa! Julio 1891)—Prov. Tokachi: Obihiro (S. Hashimoto! 1890; T. Obanawa! Julio 1892); Memoro. (S. Nishida! Julio 1914).—Prov. Kushiro: Setsuri (Sukeo Ito! Aug. 1895).—Prov. Nemuro: inter Tobuto et Bekkai (Y. Kudo! n. 3371, Julio 1917); Shunbetsu (Jo Tanaka! Sept. 1895); Bentenjima (M. Nakamura! Aug. 1884).—Prov. Kitami: inter Furetoi et Abashiri (Y. Kudo! n. 3465, Julio 1917); inter Shari et Furetoi (Y. Kudo! Julio 1917); Hamatombetsu (S. Nishida! Aug. 1917); Shari-sando (K. Miyabe! Julio 1884); ins. Rebun (K. Miyabe! Aug. 1894); Bensashi in ins. Rebun (Y. Kudo! n. 1788, Julio 1916); ins. Rishiri (S. Hori! Aug. 1887; W. Hirose! Julio 1896; T. Yagihashi! Julio 1910).

*Chishima.* Ins. Kunashiri: Keramui, prope oppid. Tomarimura (C. Yendo! Julio 1894).—Ins. Shikotan: Shakotan (Miyabe f. et Tanaka! Aug. 1910); Anama (M. Arai! Aug. 1910).—Ins. Etorofu: Shimonaibo (K. Miura! Julio 1906).



DISTRIB. Sachalin, insulae Kurilenses australes, Hokkaido et Honshu.

A *Scutellaria scordifolia* Fisch. mihi ex descriptione Benthami\* nota, differe videtur, foliorum forma, caulis habitu, et multis notis.

#### 4. **Agastache** Clayt.

11. **Agastache rugosa** O. Ktze. Rev. Gen. Pl. II. (1891) p. 511; Briq. Labiat. in Engl. u. Prantl. Nat. Pfl.-fam. IV. 8. (1897) p. 234; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 535; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 296.

*Lophanthus rugosus* Fisch. et Mey. Ind. Sem. Hort. Petrop. I. (1835) p. 30; Benth. in DC. Prodr. XII. (1848) p. 369; Maxim. Prim. Fl. Amur. (1859) p. 218; Rgl. Tent. Fl. Ussuri (1862) p. 117; Miq. Prol. Fl. Jap. (1866-67) p. 41; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 373; Franch. Pl. David. I. p. 237; Herder. Pl. Radd. Monop. et in Act. Hort. Petrop. X. I. p. 3 (1885); Forb. et Hemsl. Ind. Fl. Sin. II. (1889-1902) p. 288; Diels. Fl. Centr. China, in Engl. Bot. Jahrb. XXIX. (1901) p. 553; Kom. Fl. Mansh. III. (1907) p. 349; Nakai, Fl. Korea. II. (1911) p. 149; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 543; Dunn et Tutchet, Fl. Kwangt. et Hongk. (1912) p. 210; Dunn, Key Labiat. China, in Notes Roy. Bot. Gard. Edinb. VI. Numb. XXVIII. (1915) p. 165.

*Elsholtzia monostachys* Lév'l. et Vnt., in Fedde, Repert. Nov. Spec. VIII. (1910) p. 424, fide Dunn.

var. **hypoleuca** (Maxim.) Kudo. (Tab. I, fig. 11.).

*Lophanthus rugosus* Fisch. et Mey., var. *hypoleuca* Maxim. apud Herder l. c. p. 4, nom. nud.

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\* Benth. in DC. Prodr. XII. p. 425.—“*S. scordifolia*, *glabra* caule ramoso foliis imis petiolatis ovatis superioribus breviter petiolatis, *oblongo-lanceolatis* obtusis *integerrimis* vel *remote serratis* basi *rotundatis* vel *cuneatis*, rarius *subhastatis*, etc.”



Folia supra glabra, vel parce puberulentia, subtus discoloria, dense pubescentia, utrinque non rugosa.

NOM. JAP. *Kita-kawamidori* (nov.).

HAB. *Hokkaido*. Prov. Oshima: monte Sasayama, prope oppid. Esashi (Y. Kudo! n. 3788, Aug. 1917); inter Fukuyama et Shirakami (Y. Kudo! n. 3785, Aug. 1917); ad fl. Shimmei, prope oppid. Fukuyama (Miyabe et Tokubuchi! Julio 1890; Y. Kudo! n. 3784, Aug. 1917); Esashi (Miyabe et Tokubuchi! Aug. 1890); Notappu (Y. Tokubuchi! Aug. 1888).—Prov. Shiribeshi: ins. Okushiri (Miyabe et Tokubuchi! Julio 1890); Zenibako (Y. Kudo! n. 2798, Sept. 1917).—Prov. Iburi: Muroran (Y. Kudo! n. 4016, Aug. 1917); inter Date et Sobetsu (Y. Kudo! n. 4017, Aug. 1917); inter Washibetsu et Date (Y. Kudo! n. 4018, Aug. 1917).—Prov. Hidaka: Fuyushima (Y. Kudo! n. 605, Aug. 1914); Shoya (Y. Kudo! n. 604, Aug. 1914); inter Horoman et Horoidzumi (Y. Kudo! n. 603, Sept. 1914); in monte Orokunne-nupuri (Y. Kudo! n. 606, Aug. 1914); Samani-sando (K. Kondo! Aug. 1912); Saruru-sando (K. Miyabe! Aug. 1884); Saruru (Y. Tokubuchi! Aug. 1892); Horoidzumi (Y. Tokubuchi! 1893).—Prov. Ishikari: Sapporo (Class'80! Aug. 1878; Kitago! Aug. 1881); Hassabu (T. Sakamura! Aug. 1912; M. Takenouchi! Sept. 1917); monte Moiwa (H. Kihara! Oct. 1916); Kamuikotan (K. Miyabe! Aug. 1891); Manju (F. C. Greatrex! Aug. 1915); Poronai Tanzan (Y. Tokubuchi! Julio 1887); monte Ashiupetnupuri (Nishida et Yanagisawa! Aug. 1913).—Prov. Kushiro; Panke ad lacum Akan (I. Muto! Aug. 1917); Akkeshi (Yamanouchi! Aug. 1913).—Prov. Kitami: Notoro-sando (C. Suzuki! Sept. 1916); Shonai-sando (S. Nishida! Aug. 1917).

DISTRIB. *Hokkaido* et *Honshu*.

forma **lanceolata** Kudo.

Folia oblongo-lanceolata. Cetera varietatis typicæ.

NOM. JAP. *Hosoba-kitakawamidori*.

HAB. *Hokkaido*. Prov. Hidaka: Samani (Y. Tokubuchi! Aug. 1892).

DISTRIB. *formæ*. *endemica*! DISTRIB. *speciei*. *Hokkaido*, *Formosa*, *Korea*, *Manchuria* et *China*.

### 5. *Nepeta* L.

12. *Nepeta subsessilis* Maxim. (Tab. I, fig. 12.) Mém. Biol. IX. (1874) p. 449 et in Bull. Acad. Pétersb. XX. (1875) p. 469; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 375, et II. (1879) p. 463; Yabe, Bot. Mag. Tokyo, XVII. (1903) p. 25; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 545; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 297.

*Nepeta subsessilis* Maxim., var. *yezoensis* Fr. et Sav. Enum. Pl. Jap. II. (1879) p. 464; Matsum. et Kudo, l. c.

NOM. JAP. *Misogawasô*.

HAB. *Hokkaido*. Prov. Iburi: ad fl. Mukawa (C. Yendo! Aug. 1895).—Prov. Ishikari: in monte Ashiupetnupuri (Nishida et Yanagisawa! Aug. 1915); in monte Yubari (Yanagisawa et Hamana! Aug. 1912; S. Nishida! Aug. 1913; Biyê-chubetsu (Y. Harata! Julio 1919); ad pedem montis Nutakukamshupe (H. Koidzumi! Julio 1911); Sapporo (Takenobu! Julio 1881).—Prov. Tokachi: secus fl. Memoro (T. Obanawa! Aug. 1892).—Prov. Kushiro: in monte Meakan (T. Kawakami! Aug. 1897); Setsuri, ad oppid. Shitakara (Sukeo Ito! Aug. 1895); Akubetsu (T. Kawakami! Aug. 1897).—Prov. Nemuro: Kauchiushi (K. Miyabe! Julio 1884).—Prov. Kitami: in ins. Rishiri, monte Rishiri (W. Hirose! Aug. 1896; S. Hori! Aug. 1887; T. Kawakami! Aug. 1899); in ins. Rebun (K. Miyabe! Aug. 1894); ins. Rebun, inter Futanami et Obashitomanai (Y. Kudo!

n. 1784, Julio 1916); ins. Rebun, prope Wiennai (Y. Kudo!  
n. 1785, Julio 1916).

DISTRIB. Hokkaido, Honshu et Shikoku.

forma **interrupta** Kudo.\*

*Nepeta macrantha* Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 375,  
(non Fisch.).

Racemus valde interruptus, verticillastris paucifloris, remotis.

NOM. JAP. *Okuyama-misogawasō*.

HAB. *Hokkaidō*. Prov. Tokachi: monte. memoro (S. Nishida!  
Julio 1914).

DISTRIB. Hokkaido et Honshu.

## 6. **Glecoma** L.

13. **Glecoma hederacea** L. Spec. Pl. ed. 1. (1753) p. 578;  
Thunb. Fl. Jap. (1784) p. 246; Maxim. Prim. Fl. Amur. (1859) p.  
218; Britt. et Brown, Ill. Fl. III. (1898) p. 87; Diels, Fl. Centr.  
China, in Engl. Bot. Jahrb. XXIX. (1901) p. 553; Yabe, Bot. Mag.  
Tokyo, XVIII. (1904) p. 42; Kom. Fl. Mansh. III. (1907) p. 355;  
Matsum. Ind. Pl. Jap. II. 2. (1912) p. 540; Matsum. et Kudo, Bot.  
Mag. Tokyo, XXVI. (1912) p. 297.

*Nepeta Glecoma* Benth. Lab. (1834) p. 485, et in DC. Prodr.  
XII. (1848) p. 391; Sieb. et Zucc. Fl. Jap. Fam. Nat. (1846) n.  
538; Ledeb. Fl. Ross. III. (1847-49) p. 379; A. Gray, Pl. Jap.  
(1856) p. 316; Miq. Prol. Fl. Jap. (1866-67) p. 41 ( $\alpha$ . et  $\beta$ . *hirsuta*);  
Herder, Pl. Radd. Monop. et in Act. Hort. Petrop. X. I. p. 4; Maxim.  
Mél. Biol. IX. (1874) p. 450; Fr. et Sav. Enum. Pl. Jap. I. (1875)  
p. 375; Franch. Pl. David. p. 238; Baker et Moore, in Journ. Linn.

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\* Etiam occurit duæ formæ. Forma **Fauriei** (Lév'l.) Kudo (= *Nepeta Fauriei* Lév'l. in Fedde Repert. IX. [1911] p. 245) inflorescentiam univerticillatam habet; hab. in monte Iide, et forma **pauciflora** Kudo, cymis bifloris, foliis lanceolato-oblongis; hab. in monte Komagadake, Prov. Kai (K. Watanabe! Aug. 1895).

Soc. XVIII. p. 385; Debeaux, Fl. Shangh. p. 46 (var. *hirsuta*); Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 290; Matsum. et Hayata, Enum. Pl. Formos. (1906) p. 313; Dunn and Tutcher, Fl. Kwangt. et Honkg. (1912) p. 210; Dunn, Key Lab. China, in Notes Roy. Bot. Gard. Edinbg. Vol. VI. Numb. XXVIII. (1915) p. 167.

var. **grandis** (A. Gray) Kudo. (Tab. I, fig. 13.).

*Nepeta Glechoma* Benth., var. *grandis* A. Gray, Bot. Jap. (1858) p. 402.

*Nepeta Glechoma* Benth., var. *grandiflora* Herder, l. c. p. 6, quoad Pl. Jap. (non Fies.).

? *Lamium purpureum* Thunb. Fl. Jap. (1784) p. 246; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 380, (non L.).

*Glechoma grandis* Kudo, Mss.

NOM. JAP. *Kakidōshi*, *Kantorisō*.

HAB. *Hokkaido*. Prov. Oshima: Fukuyama (Y. Kudo! n. 3783, Aug. 1917); Fukuyama (Y. Tokubuchi! Aug. 1888); Hakodate (S. Nozawa! Julio 1886); Taniyoshi (Miyabe et Tokubuchi! Julio 1890); prope Hakodate (F. C. Greatrex! Maio 1916); Nanae (F. C. Greatrex! Apr. et Maio 1916).—Prov. Shiribeshi: in ins. Okushiri, ad oppid. Tsurikake (Y. Kudo! n. 2598, Aug. 1916).—Prov. Ibari: Oiwake (K. Miyabe! Junio 1894; Y. Tokubuchi! Aug. 1893).—Prov. Ishikari: in silvis Nopporo (K. Tsutsuki! Maio 1918); Garugawa (M. Takenouchi! Maio 1917).

DISTRIB. *varietatis*. *Hokkaido*, *Honshu*, *Kiushu*; *speciei* *China*, *Manchuria*, *Kamtschatka*, per regiones *Sibiriae orientalem*, *baicalensemque altaicam*, usque ad *Europam extensa*; in *Americam borealem* *introducenda*.

## 7. *Dracocephalum* L.

14. *Dracocephalum japonicum* Kudo. (Tab. I, fig. 14.).

*Dracocephalum Ruyschianum* L., var. *japonicum* A. Gray, Bot. Jap. (1858) p. 403; Miq. Prol. Fl. Jap. (1866-67) p. 41; Herder, Pl. Radd. Monop. et in Act. Hort. Petrop. X. I. p. 14; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 539.

*Dracocephalum Ruyschianum* Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 376, (non L.).

*Dracocephalum argunense* Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 297, (non Fisch.).

NOM. JAP. *Musha-rindō*.

HAB. *Hokkaido*. Prov. Oshima: prope Yunokawa (F. C. Grea-trex! Julio 1916); Hakodate (S. Nozawa! 1886).—Prov. Shiribeshi: Raidentoge (T. Ishikawa! Junio 1897); Yoichi, Hamanaka (Takenobu et Mimasu! Julio 1883); Oshoro (Y. Tokubuchi! Julio 15, 1888).—Prov. Iburi: Yakumo (Y. Odagiri! Julio 1894).—Prov. Ishikari: Ishikarimura (K. Miyabe! Aug. 1885).—Prov. Kushiro: Setsuri, Shitakara (Sukeo Ito! Aug. 1895); Tonkeshi (M. Nakamura! Julio 1886).—Prov. Nemuro: inter Tobuto et Bekkai (Y. Kudo! n. 3376, Julio 1917).—Prov. Kitami: inter Shari et Furetoi (Y. Kudo! n. 3464, Julio 1917); inter Furetoi et Abashiri (Y. Kudo! n. 3463, Julio 1917); Shari (K. Miyabe! Julio 1884; T. Ishikawa! Julio 1890); in ins. Rebun, ad Bensashi (Y. Kudo! n. 1789, Julio 1916).

DISTRIB. *Hokkaido* et *Honshu*.

Species igitur media inter *Dracocephalum Ruyschianum*\* et *Dracocephalum argunense*.\*.\* A priore differt foliis tenuiter pubes-

\* *Dracocephalum Ruyschianum* L. Spec. Pl. ed. I. (1753) p. 595; Benth. in DC. Prodr. XII. (1848) p. 402; Ledeb. Fl. Alt. II. (1830) p. 388; Thomé, Fl. Deutsch. Öst. u. Schw. IV. p. 127.

*Dracocephalum Ruyschianum* L., *α. vulgare* Ledeb. Fl. Ross. III. (1847-1849) p. 389.—Hab. *Dahuria*, *Sibiria*, *Caucasia* et *Europa*.

\*\* *Dracocephalum argunense* Fischer, in Link. Enum. Pl. Hort. Berol. II. p. 118; Benth. in DC. Prodr. XII. (1848) p. 402; Herder, Pl. Radd. in Act. Hort. Petrop. X. I. p. 15; Freyn. in Oesterr. Bot. Zeit. (1902) p. 407; Kom. Fl. Mansh. III. (1907) p. 356, excl. Syn. *D. Ruyschianum*. *B. japonicum* A. Gray.

centibus nec glabris, bracteis aristato-ovatis, villosa-ciliatis, calycibus albo-hirsutis, nec pubescentibus, dentibus calycinis subæqualibus, nec dente supremo ovato, nec infimis lanceolatis, corollis multo majoribus; a posteriore caulibus pubescentibus nec glabris, foliis margine nec revolutis non glabris, bracteis nec cuneato-ellipticis, calycem æquantibus nec eo brevioribus, nec glaberrimis non bilabiatis.

### 8. *Prunella* L.

15. *Prunella vulgaris* L. Spec. Pl. ed. 1. (1753) p. 600; Thunb. Fl. Jap. (1784) p. 250; Benth. in Linnaea. VI. p. 80 et in DC. Prodr. XII. (1848) p. 410; Ledeb. Fl. Alt. II. (1830) p. 382 et Fl. Ross. III. (1846-51) p. 392; Bongard, Végétation de Sitcha (1831) p. 159; A. Gray, Pl. Jap. (1856) p. 316 et Bot. Calif. I. (1880) p. 477; Miq. Prol. Fl. Jap. (1866-67) p. 42; Wight, Ic. t. 1448; Boiss. Fl. Orient. IV. p. 691; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 376; Hance, Jour. Bot. (1882) p. 38; Hook. f. Fl. Brit. Ind. IV. (1885) p. 670; Herder. Pl. Radd. Monop. et in Act. Hort. Petrop. X. 1. p. 15; Franch. Pl. David. I. (1884) p. 241; Britt. and Brown, Ill. Fl. III. (1898) p. 88; Baker et Moore, in Journ. Linn. Soc. Bot. XVII. p. 385; Forb. et Hemsl. Ind. Fl. Sin. II. (1889-1902) p. 299; Thomè, Fl. Deutsch. Oest. u. Schw. IV. p. 109; Briq. Labiat. in Engl. u. Prantl. Nat. Pfl.-fam. IV. 3. a. (1897) p. 241; Palib. Consp. Fl. Korea. II. (1900) p. 29; Diels, Fl. Centr. China, in Engler, Bot. Jahrb. XXIX. (1901) p. 554; Yabe, Bot. Mag. Tokyo, XVIII. (1904) p. 43; Loesner, in Engler, Bot. Jahrb. Beiblatt. Nr. XXXIV. (1905) p. 63; Matsum. et Hayata,

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*Dracocephalum Ruyschianum* L., *β. speciosum* Ledeb. Fl. Ross. III. (1846-1851) p. 390; Korsh. Pl. Amur. (1892) p. 377.

*Dracocephalum Ruyschianum* Franch. Pl. David. (1884) p. 240; Forb. et Hemsl. Ind. Fl. Sin. II. (1889-1902) p. 292; Dunn, Key Lab. China, in Notes, R. B. G. Edinbg. Vol. VI. Numb. XXVII. (1915) p. 169, (non L.).

*Dracocephalum Ruyschianum* L., *β. argenteum* Nakai. Fl. Korea. II. (1911) p. 150. Hab. Korea, China, Manchuria, Amur, Ussuri et Dahuria.



Enum. Pl. Formos. (1906) p. 314; Piper. Fl. St. Washington (1906) p. 489; Nakai, Fl. Korea, II. (1911) p. 147; Dunn, Key. Lab. China, in Notes Roy. Bot. Gard. Edinbg. Vol. VI. Numb. XXVIII. (1915) p. 177.

var. **japonica** (Makino) Kudo. (Tab. I, fig. 15.).

*Prunella vulgaris* L., var. *vulgaris* Makino, Bot. Mag. Tokyo X (1896) p. 66; Matsum. Ind. Pl. Jap II. 2. (1912) p. 537; Matsum. et Kudo, Bot. Mag. Tokyo XXVI. (1912) p. 297, (non Benth).

*Prunella japonica* Makino, Bot. Mag. Tokyo, XXVIII. (1914) p. 158.

*Prunella vulgaris* L., var. *yezoënsis* Kudo. MSS.

NOM. JAP. *Yezo-utsubogusa*, *Miyama-utsubogusa*.

HAB. *Hokkaido*. Prov. Oshima: inter Fukuyama et Yoshioka (Y. Kudo! n. 3778, Aug. 1917); inter Fukuyama et Tateishino (Y. Kudo! n. 3779, Aug. 1917); Hakodate (Y. Tokubuchi! Julio 1888; F. C. Greatrex! Junio 1916); Kamiiso (Miyabe et Tokubuchi! Julio 1890); Mohechi (S. Ninoue! Julio 1906).—Prov. Iburi: Yakumo (Y. Odagiri! Julio 1894); Mukawa (C. Yendo! Junio 1895); monte Makkarinupuri (M. Takayama! Aug. 1910).—Prov. Hidaka: Horoidzumi (Y. Tokubuchi! Aug. 1892).—Prov. Ishikari: Garugawa (Y. Kudo! n. 4355, Junio 1918); monte Teine (Y. Kudo! n. 4356, Julio 1918); in silvis Nopporo (Y. Kudo! n. 1322, Sept. 1915); in monte Yubari (Yanagisawa et Hamana! Aug. 1912; Yanagisawa! Aug. 1913; S. Nishida! Aug. 1913); Omagari, ad oppid. Hiroshima (K. Tsutsuki! Junio 1918); Sapporo (Class'80! Junio 1878); Hassabu (T. Sakamura! Aug. 1912); Yamahana (J. Iwasaki! Julio 1913); Kamuimetokunupuri (S. Igarashi! Aug. 1915).—Prov. Teshio: in silvis Teshio (Y. Kudo! n. 4574, Julio 1919).—Prov. Tokachi: in monte Saoro (S. Nishida! Aug. 1913); monte Satsunaitake (S. Nishida! Julio 1917).—Prov. Kushiro: Akkeshi (Y. Kudo!

n. 3099, Julio 1917); Ruriran (Y. Kudo! n. 3097, Julio 1917); Kiritappu (Y. Kudo! n. 3098, Julio 1917); Kushiro (K. Nishikawa! 1914); ad pedem montis Meakan (T. Kawakami! Aug. 1897); Beshika (M. Nakamura! Julio 1888).—Prov. Nemuro: Nemuro (T. Yagihashi! Aug. 1910; D. Hoshi! Julio 1911).—Prov. Kitami: Kosukawa (Y. Kudo! n. 3462, Julio 1917); Shari-sando (K. Miyabe! Julio 1884); Okoppe (S. Yokoyama! Julio 1892).

*Chishima*. Ins. Etorofu: Shana (Miyabe f. et Tanaka! Julio 1910); inter Bettobu et Shamambe (K. Miura! Julio 1906); prope Furebetsu (K. Miyabe! Julio 1884); Rubetsu (T. Kawakami! Aug. 1898).

DISTRIB. *varietatis*. Insulae Kurilenses, Hokkaido et Honshu; *speciei* Asia temperata, Sibiria orientalis, baikalensis, uralensis et altaica, ins. Sitcha, Himalaya temperata, Tibet occidentalis, Europa, America borealis temperata, Australia, Andes.

### 9. *Chelonopsis* Miq.

16. *Chelonopsis moschatus* Miq. (Tab. I, fig. 16.) in Ann. Mus. Bot. Lugd. Bat. II. p. 111 et Prol. Fl. Jap. p. 43 (1866–67); Maxim. in Mém. Biol. IX. (1874) p. 443; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 378; Briq. Labiat. in Engl. u. Prantl. Nat. Pfl.-fam. IV. 3. a. (1897) p. 243; Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 298 (*var. foliis minute serratis*); Matsum. Ind. Pl. Jap. II. 2. (1912) p. 537; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 297; Dunn, Key Labiat. China, in Notes Roy. Bot. Gard. Edinbg. VI. Numb. XXVIII. (1915) p. 178.

NOM. JAP. *Jakosō*.

HAB. *Hokkaido*. Gamushi (Y. Kudo! n. 3781, Aug. 1917); Todogawa (Y. Kudo! n. 3780, Aug. 1917); inter Fukuyama et Shinmeizawa (Y. Kudo! n. 3782, Aug. 1917); Shikabe (K. Miyabe!

Aug. 1890); Yesashi (Miyabe et Tokubuchi! Aug. 1890); Tōgenoshita (Y. Tokubuchi! Aug. 1888); Fukuyama (Y. Tokubuchi! Aug. 1888); in monte Hakodate (S. Nosawa! Sept. 1886); Hakodate (F. C. Greatrex! Sept. 1915).—Prov. Shiribeshi: in insula Okushiri, inter Tsurikake et Kan-no-ma (Y. Kudo! n. 2640, Aug. 1916); in insulæ Okushiri, monte Kamui (Y. Kudo! n. 2378, Aug. 1916); Zenibako (Y. Tokubuchi! Sept. 1890); Kumaishi (Miyabe et Tokubuchi! Julio 1890); Togappu, prope oppid. Ōe (I. Yamamoto! Oct. 1914).—Prov. Hidaka: Samani-sando (K. Miyabe! Aug. 1884; K. Kondo! Aug. 1912).—Prov. Ishikari: in monte Teine (Y. Tokubuchi! Aug. 1887); Sapporo (Class'80! Sept. 1878); Hassabu (H. Yanagisawa! Aug. 1915; T. Sakamura! Aug. 1912; M. Takenouchi! Sept. 1917); in monte Moiwa (T. Sakamura! Aug. 1912).

DISTRIB. Hokkaido, Honshu, Shikoku, China et Hongkong.

#### 10. *Galeopsis* L.

17. *Galeopsis Tetrahit* L. Spec. Pl. ed. 1. (1753) p. 579; Ledeb. Fl. Alt. I. (1830) p. 406 et Fl. Ross. III. (1846–51) p. 420; Benth. in DC. Prodr. XII. (1848) p. 498; Fr. Schm. Fl. Sachal. (1868) p. 165; A. Gray, Syn. Fl. N. Am. II. 1. (1878) p. 385 et Bot. Calif. I. (1880) p. 590; Hook. f. Fl. Brit. Ind. IV. (1885) p. 677; Miyabe, Fl. Kuril. (1890) p. 225; Korsh. Pl. Amur (1892) p. 379; F. Kurtz, Fl. Chileat, Südl. Alaska, in Engl. Bot. Jahrb. XIX. (1895) p. 402; Thomé, Fl. Deutsch. Oest. u. Schw. IV. p. 112; Britt. et Brown, Ill. Fl. III. (1898) p. 92; Kom. Fl. Mansh. III. (1907) p. 363; Koidz. Pl. Sachal. Nakah. (1910) p. 106; Nakai, Fl. Korea. II. (1911) p. 153; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 540; Miyabe and Miyake, Fl. Saghalin (1915) p. 369; Dunn, Key. Lab. Chin. in Notes Roy. Bot. Gard. Edinbg. VI. Numb. XXVIII. (1915) p. 181.

var. **bifida** Syme, (Tab. I, fig. 17.) Engl. Bot. ed. 3. VII. p. 67; Takeda, Fl. Shikotan (1914) p. 482.

*Galeopsis bifida* Bönninghausen, Fl. Monast. Prodr. p. 178.

*Galeopsis Tetrahit* L., var. *parviflora* Benth. in DC. Prodr. XII. (1848) p. 498; Ledeb. Fl. Ross. II. (1846–51) p. 420; Trautv. et Mey. Fl. Ochot. (1856) p. 73; Maxim. Prim. Fl. Amur. (1859) p. 220; Herder, Pl. Radd. Monop. et in Act. Hort. Petrop. X. 1. p. 35.

*Galeopsis Tetrahit* L., subsp. *bifida* Fries, var. *bifida* Lej. et Court: Briq. Labiat. in Engl. u. Prantl., Nat. Pfl.-fam. IV. 3. a. (1897) p. 253.

NOM. JAP. *Chishima-odorikoso*, *Itachi-jiso*.

HAB. *Hokkaido*. Prov. Hidaka: Horoidzumi (Y. Tokubuchi! Aug. 1892); Shoya (Y. Tokubuchi! Aug. 1892).—Prov. Kushiro: Setsuri, Shitakara (Sukeo Ito! Aug. 1895); Kushiro (D. Hoshi! Sept. 1910); Tottori (K. Takahashi! Aug. 1913).—Prov. Nemuro: Nemuro (M. Nakamura! Aug. 1884); Bentenjima (K. Miyabe! Aug. 1884).—Prov. Kitami: Shari (K. Miyabe! Aug. 1894); Esashi (T. Yagihashi! Aug. 1910).

*Chishima*. Ins. Kunashiri: Tomarimura (S. Yokoyama! Junio, 1891).—Ins. Shikotan: Shikotan (K. Miyabe! Julio 1884; T. Kawakami! Aug. 1898; Miyabe f. et Tanaka! Aug. 1910); Anama (H. Takeda! Aug. 1909).—Ins. Etorofu: Anama (Miyabe f. et Tanaka! Aug. 1910); Shana (T. Kawakami! Sept. 1898; Miyabe f. et Tanaka! Julio 1910); Rubetsu (T. Kawakami! Aug. 1898).

DISTRIB. var. *Sachalin*, insulæ *Kurilenses*, *Hokkaido*, *Honshu*, *Himalaya*, *Siberia orientalis* usque ad *Irlandiam* et *insulam Faroe*; *sp.* *Korea*, *Manchuria*, *China*, *Amur*, *Kamtschatka*, *Siberia (orientalis, baikalensis, altaica, uralensis)*, *Dahuria*, *Sikkim-Himalaya*, *Caucasia*, *Europa* et in *Americam borealem* *introducta*.

11. **Lamium** L.

## CLAVIS SPECIERUM DICHOTOMA.

Folia suborbiculato-reniformia, margine crenulata. Corollæ tubus intus nudus ..... *L. amplexicaule* L.

Folia ovata, ovato-cordata, margine inæqualiter serrulata. Corollæ tubus intus pilosus ..... *L. album* L., var. *barbatum* Fr. et Sav.

18. **Lamium amplexicaule** L. (Tab. I, fig. 18.) Spec. Pl. ed. 1. (1753) p. 579; Thunb. Fl. Jap. (1784) p. 247; Benth. in DC. Prodr. XII. (1848) p. 508; Ledeb. Fl. Ross. III. (1846–1851) p. 427; A. Gray, Pl. Jap. (1857) p. 316 et Syn. Fl. North. Am. II. 1. (1878) p. 385; Miq. Prol. Fl. Jap. (1866–67) p. 45; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 380; Herder, Pl. Radd. Monop. VIII. et in Act. Hort. Petrop. X. 1. p. 40; Hook. f. Fl. Brit. Ind. IV. (1885) p. 679; Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 303; Henry, List Pl. Formos. p. 73; Britt. and Brown, Ill. Fl. III. (1898) p. 94; Palib. Consp. Fl. Korea. II. (1900) p. 31; Diels, Fl. Centr. China, in Engl. Bot. Jahrb. XXIX. (1901) p. 555; Yabe, Bot. Mag. Tokyo, XVIII. (1904) p. 43; Matsum. et Hayata, Enum. Pl. Formos. (1906) p. 317; Piper, Fl. St. Washington (1906) p. 490; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 541; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 298.

NOM. JAP. *Hotokenoza*.

HAB. *Chishima*. Shana (Sanada! 1895).

Distrib. Insulæ Kurilenses, Japonia, Korea, Manchuria, China, Sibiria (baicalensis, altaica, et uralensis); Panjab, Himalaya, Tibet occidentalis, Nepalia, Afghanistan, Turkestan, Persia, Mesopotania, Caucasia, Europa, Africa borealis et in Americam borealem importat.

19. **Lamium album** L. Spec. Pl. ed. 1. (1753) p. 579; Ledeb. Fl. Alt. II. (1830) p. 406 et Fl. Ross. III. (1846–51). p. 429;



Maxim. Prim. Fl. Amur. (1859) p. 221; Rgl. Tent. Fl. Ussuri (1862) p. 120; Herder, Pl. Radd. Monop. et in Act. Hort. Petrop. X. 1. p. 42 (*α. genuinum*); A. Gray, Syn. Fl. North Am. II. 1. (1878) p. 385; Boiss. Fl. Orient. IV. p. 763; Hook. f. Fl. Brit. Ind. IV. (1885) p. 679 (var. *barbatum*); Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 302; Franch. Pl. David. I. p. 241; Britt. and Brown, Ill. Fl. III. (1898) p. 95; Diels, Fl. Centr. China, in Engl. Bot. Jahrb. XXIX. (1901) p. 555; Kom. Fl. Mansh. III. (1907) p. 364.

var. *barbatum* Fr. et Sav. (Tab. II, fig. 19.) Enum. Pl. Jap. I. (1875) p. 380; Herder, Pl. Radd. in Act. Hort. Petrop. X. 1. p. 42.

*Lamium barbatum* Sieb. et Zucc. Fl. Jap. Fam. Nat. II. p. 158; Benth. in DC. Prodr. XII. (1848) p. 511; Fr. Schm. Fl. Amg.-Bur. (1868) p. 59.

*Lamium garganicum* Thunb. Fl. Jap. (1784) p. 246, (non L.).

*Lamium maculatum* Maxim. Prim. Fl. Amur. (1859) p. 221, (non L.).

*Lamium album* Miq. Prol. Fl. Jap. (1866–67) p. 45; Yabe, Bot. Mag. Tokyo, XVIII. (1904) p. 43; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 540, (non L.).

*Lamium petiolatum* A. Gray, Pl. Jap. (1857) p. 316; Kom. Fl. Mansh. III. (1907) p. 365, (non Royle).

*Lamium album* L., var. *petiolatum* Nakai, Fl. Korea. II. (1911) p. 154.

NOM. JAP. *Odorikosō*.

HAB. *Hokkaido*. Prov. Oshima: Hakodate (S. Nozawa! Maio, 1886); Akagawa, prope Hakodate (F. C. Greatrex! Junio 1916); Nanae (F. C. Greatrex! Maio 1916).—Prov. Shiribeshi: Shimakotan (T. Ishikawa! Maio 1897); insula Okushiri (K. Miyabe! Julio 1890); in ins. Okushiri, inter Poronai et Aonai (Y. Kudo! n. 2519).



Aug. 1916); ins. Okushiri, oppid. Tsurikake (Y. Kudo! Aug. 1916).—Prov. Hidaka: Saruru (K. Miyabe! Junio 1884).—Prov. Ishikari: inter Ishiyama et Misomai (Y. Kudo! n. 4357, Junio 1918); Shimo-Teine (M. Takenouchi! Junio 1917); in silvis Nopporo (K. Tsutsuki! Junio 1918); Sapporo (Class'80! Junio 1878; Y. Kudo! Maio 1915).—Prov. Tokachi: Birō (K. Miyabe! Junio 1884); Uraboro (K. Toganoo! Maio 1895).—Prov. Kushiro: ins. Daikoku, prope Akkeshi (Y. Kudo! n. 3100, Julio 1907).—Prov. Nemuro: Nemuro (M. Nakamura! Junio 1885; D. Hoshi! Maio 1912).—Prov. Kitami: inter Shibetsu et Itokushibetsu (Y. Kudo! n. 3370, Julio 1917); Koētoi, prope Wakkanai (H. Ishidoya! Oct. 1916); ad. fl. Sarubutsu (T. Ishikawa! 1892).

*Chishima*. Ins. Kunashiri: Tomarimura (S. Yokoyama! Junio, 1891).

DISTRIB. *var.* Sachalin, insulae Kurilenses, Hokkaido, Honshu Shikoku, Kiushu, Korea, Manchuria et Amur; *sp.* Korea, Manchuria, China, Amur, Kamtshatka, Sibiria (orientalis, baicalensis, altaica et uralensis), Dahuria, Sikkim-Himalaya, Caucasia, Europa, in Americam borealem introducta.

## 12. *Leonurus* L.

### CLAVIS SPECIERUM DICHOTOMA.

Folia simplicia, margine duplicato-serrata. Flores ca. 3 cm longi. Calycis dentes inferiores altius connati. Corollae tubus intus dense hirsutus, parte inferiore hirsuto-annulatus.....*L. macranthus* Maxim.

Folia ad basin tripartita, segmentis partitis v. fidis. Flores ca. 1.1 cm longi. Calycis dentes inferiores paulo connati. Corollae tubus intus parce pilosus, parte inferiore annulo oblique parum prominulo piloso praeditus...*L. sibiricus* L.

20. *Leonurus macranthus* Maxim. (Tab. II, fig. 20.) in Ind. Fl. Pek. in Prim. Fl. Amur. (1859) p. 476 et Mém. Biol. IX.

(1874) p. 445; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 379; Franch. Pl. David. I. p. 244, et Mem. Soc. Sc. Nat. Cherbourg. XXIV. p. 244; Heder, Pl. Radd. Monop. et in Act. Hort. Petrop. X. 1. p. 37; Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 302; Palib. Consp. Fl. Korea. II. (1900) p. 30; Yabe, Bot. Mag. Tokyo, XVIII. (1903) p. 43; Loesner, in Engler, Bot. Jahrb. XXXIV. Beiblatt (1905) p. 63; Kom. Fl. Mansh. III. (1907) p. 367; Nakai, Fl. Korea. II. (1911) p. 155; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 541; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 298; Dunn, Key Labiat. China, in Notes Roy. Bot. Gard. Edinbg. Vol. VI. Numb. XXVIII. (1915) p. 182.

*Leonurus japonicus* Miq. in Ann. Mus. Bot. Lugd. Bat. II. p. 112, et Prol. Fl. Jap. p. 44, (1866–67).

NOM. JAP. *Kisewata*.

HAB. *Hokkaido*. Prov. Oshima: Yunokawa (F. C. Greatrex! Aug. 1916); Yesashi (Miyabe et Tokubuchi! Julio, 1890).—Prov. Iburi: Mukawa (Y. Tokubuchi! Aug. 1892).—Prov. Ishikari: Sapporo (Class'84! 1882; Y. Tokubuchi! Oct. 1890).

DISTRIB. *Hokkaido*, *Honshu*, *Kiushu*, *Tsushima*, *Korea*, *Manchuria*, *China boreali-orientalis*.

21. ***Leonurus sibiricus*** L. (Tab. II, fig. 21.) Spec. Pl. ed. 1. (1753) p. 584; Benth. in DC. Prodr. XII. (1848) p. 501; Ledeb. Fl. Ross. III. (1846–51) p. 425; Maxim. Prim. Fl. Amur. (1859) p. 221, 476; Regel, Tent. Fl. Ussuri (1862) p. 120; Miq. Prol. Fl. Jap. (1866–67) p. 45; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 380; A. Gray, Syn. Fl. North Am. II. 1. (1878) p. 385; Hook. f. Fl. Brit. Ind. IV. (1885) p. 678; Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 302; Korsh. Pl. Amur. (1892) p. 379; Britt. and Brown, Ill. Fl. III. (1898) p. 93; Diels, Fl. Centr. China, in Engl. Bot. Jahrb. XXIX. (1901) p. 555; Yabe, Bot. Mag. Tokyo, XVIII.

(1903) p. 43 ; Loesner, in Engl. Bot. Jahrb. XXXIV. (1904) Beiblatt. Nr. 75, p. 63 ; Matsum. et Hayata, Enum. Pl. Formos. (1906) p. 316 ; Nakai, Fl. Korea. II. (1911) p. 155 ; Matsum. Ind. Pl. Jap. II. 2. (1911) p. 541 ; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 298 ; Dunn et Tutchet, Fl. Kwang. and Hongk. (1912) p. 211 ; Dunn, Key Labiat. China, in Notes Roy. Bot. Gard. Edinbg. Vol. VI. Numb. XXVIII. (1915) p. 182.

NOM. JAP. *Mehajiki*.

HAB. *Hokkaido*. Prov. Oshima : Sawara (K. Miyabe ! Aug. 1890).

DISTRIB. *Hokkaido*, *Honshu*, *Formosa*, *Korea*, *China*, *Manchuria*, *Amur*, *Sibiria* (*baikalensis* et *altaica*), *Cochinchina*, *Indiæ orientales*, *Timor*, *Philippin*, *Africa* (*Senegambia*), *insulæ Indiæ occidentales*, *Brasilia* ; et in *Americam borealem* ex seminibus asiaticis allatam fuisse videtur.

### 13. *Stachys* L.

22. *Stachys japonica* Miq. Ann. Mus. Bot. Ludg. Bat. II. p. 111, et Prol. Fl. Jap. p. 43, (1866–67).

*Stachys aspera* Michx., var. *japonica* Maxim. in Fragmenta p. 45 ; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 551.

*Stachys baicalensis* Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 378 ; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 298.

*Stachys baicalensis* Fisch., var. *japonica* Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 298.

forma a. *glabra* Matsum. et Kudo.

*Stachys japonica* Miq. Ann. Mus. Bot. Ludg. Bat. II. p. 111, et Prol. Fl. Jap. p. 43.

*Stachys aspera* Michx., var. *japonica* Maxim. Fragmenta p. 45.

*Stachys baicalensis* Fisch., var. *glabra* Matsum. et Kudo. l. c.

Folia glabra. Caulis ad angulos hispida, cetrum glaber. Calyx glaber vel parcissime pilosus.

NOM. JAP. *Kenashi-inugoma* (nov.).

HAB. *Hokkaido*. Prov. Oshima : Hakodate (ex Maximowicz).

DISTRIB. *Hokkaido*, Honshu, Kiushu.

forma b. **intermedia** Kudo.

*Stachys palustris* L., var. *hispida* Miq. Ann. Mus. Bot. Lugd. Bat. 1. p. 201, et Prol. Fl. Jap. p. 365, (non Ledeb.).

*Stachys aspera* Michx., var. *chinensis* Maxim. l. c. (p.p.) ; Matsum. Ind. Pl. Jap. l. c.

*Stachys baicalensis* Fisch., var. *japonica* Matsum. et Kudo, l. c. (non Kom.).

Folia utrinque parce hirsuta. Caulis ad angulos dense hirtus, sursum villosus. Calyx dense pilosus.

NOM. JAP. *Inugoma*, *Chōrogidamashi*.

HAB. *Hokkaido*. Prov. Oshima : Esashi (Miyabe et Tokubuchi ! Aug. 1890) ; Hakodate (Miyabe et Tokubuchi ! Aug. 1890).—Prov. Iburi : Yubuchi (J. Hanzawa ! Aug. 1899) ; Numanohata (J. Hanzawa ! Aug. 1899) ; Osatsu (Y. Tokubuchi ! Aug. 1893) ; Yakumo (Y. Odagiri ! Julio 1894).—Prov. Ishikari : Garugawa (Y. Odagiri ! Julio 1893) ; Sorachibuto (K. Miyabe ! Aug. 1891) ; Sapporo (Class' 80 ! Julio 1878 ; Y. Tokubuchi ! Sept. 1891).—Prov. Kitami : ad pedem montis Rishiri, ins. Rishiri (Y. Kudo ! n. 2059, Julio 1916).

*Chishima* : ins. Kunashiri : ad lacum Biroku, prope Ruyabetsu (C. Yendo ! Aug. 1894).

DISTRIB. *Hokkaido*, Honshu et Kiushu.

forma c. **villosa** Kudo. (Tab. II. fig. 22.).

*Stachys aspera* Michx., var. *baicalensis* Maxim. l. c. et Bull. Soc. Nat. Mosc. LIX. (1879) p. 45 ; Herder, Pl. Radd. Monop. VIII. p. 32, et in Act. Hort. Petrop. X. 1. p. 32 (p.p.) ; Miyabe, Fl. Kuril.

p. 256; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 551; Takeda, Fl. Shikotan (1914) p. 551; Miyabe et Miyake, Fl. Saghal. (1915) p. 368.

Folia utrinque pilis longis villosa. Caulis villosus et pubescens. Calyx dense villosus.

NOM. JAP. *Shirage-inugoma*.

HAB. *Hokkaido*. Prov. Iburi: inter Washibetsu et Date (Y. Kudo! n. 4030, Aug. 1917); in silvis Tomakomai (T. Yoshimi! Aug. 1914); inter Tomakomai et Yubutsu (J. Hanzawa! Aug. 1899); in monte Shikanaki, prope Tomakomai (J. Hanzawa! Aug. 1899); Oshamambe (Y. Tokubuchi! Julio 1888); Kaikuma, prope Mukawa (C. Yendo! Junio 1895).—Prov. Hidaka: inter Motoura et Urakawa (Y. Kudo! n. 625, Aug. 1914); Saruru (Y. Tokubuchi! Aug. 1892); Erimosaki (Y. Tokubuchi! Aug. 1892).—Prov. Ishikari: Sapporo (S. Enomoto! Julio 1918); Kami-Teine (M. Takenouchi! Julio 1917); Kotoni (Y. Tokubuchi! Junio 1894); in silvis Nopporo (K. Tsutsuki! Aug. 1918); Asahigawa (J. Hanzawa! Oct. 1903); Kamikawa (K. Miyabe! Aug. 1891; H. Koidzumi! 1911); Maoi (Y. Odagiri! Aug. 1894); Sorachibuto (K. Miyabe! Aug. 1891).—Prov. Tokachi: Obihiro (T. Yanagimoto! Julio 1892; T. Obanawa! Julio 1892).—Prov. Kushiro: Oboro (Y. Kudo! n. 3101, Julio 1917); Kushiro (Miyabe f. et Tanaka! Julio 1910; K. Nishikawa! 1914); Shakubetsu (M. Nakamura! Julio, 1888); Harutori (Miyabe f. et Tanaka! Julio 1910); Setsuri (Sukeo Ito! Aug. 1895).—Prov. Nemuro: inter Bekkai et Shibetsu (Y. Kudo! n. 3772, Julio 1917); inter Tobuto et Bekkai (Y. Kudo! n. 3373, Julio 1917).—Prov. Kitami: inter Shari et Furetoi (Y. Kudo! n. 3468, Julio 1917); Abashiri (T. Yagihashi! Aug. 1910); ins. Rishiri (S. Hori! Aug. 1897); ins. Rebun (S. Hori! Aug. 1887); Oshonnai, ins. Rebun (Y. Kudo! n. 1787, Julio 1916).

*Chishima*. Ins. Kunashiri: Wiennai, Tomari (C. Yendo! Julio



1894).—Ins. Shikotan: Anama (M. Arai! Aug. 1910; Miyabe f. et Tanaka! Aug. 1910); Matsugahama (Miyabe f. et Tanaka! Aug. 1910); Shakotan (T. Kawakami! Aug. 1898).—Ins. Etorofu: Shana (S. Fujimura! Aug. 1890); inter Shana et Nayoka (S. Fujimura! Aug. 1890); Rubetsu (T. Kawakami! Aug. 1898).

DISTRIB. Sachalin, insulæ Kurilenses et Hokkaido.

Species nostra valde affinis est *Stachyde chinensi* Bunge et *Stachyde baicalensi* Fisch., a quibus tamen differre videtur, foliis inferioribus longius petiolatis, nec subsessilibus, calycis dentibus divergentibus.

Planta valde polymorpha, in diversis regionibus formas diversissimas induens, tamen ver intermediis ita conjunctas, ut frustra salten in herbario, notis constantibus distinguere conatus sim.

Variat foliis angustioribus et latioribus, majoribusque minoribus, basi cordatis, rotundatis vel truncatis, floribus longioribus vel brevioribus, verticillastris paucis vel multis, approximatis vel remotis.

Forma a *glabra* videntur forma meridionalis, forma c. *villosa* forma borealis, et forma c. *intermedia* sæpe occurrit regionibus intermediis.

#### 14. *Satureia* L.

##### CLAVIS SPECIERUM VARIETATUMQUE DICHOTOMA.

- |   |   |  |
|---|---|--|
| 1 | { | Verticillastri laxe multiflori. Folia late ovata, ovata vel oblongo-ovata.<br>..... <i>S. sachalinensis</i> Kudo, var. <i>japonica</i> Kudo. |
|   |   | Verticillastri laxiflori. Folia oblongo-lanceolata .... <i>S. ussuriensis</i> Kudo.  |
|   |   | Verticillastri densissime multiflori. Folia ovata vel oblongo-ovata, apice<br>acuta, basi rotundato-cuneata .....2.                          |
| 2 | { | Flores minores, ca. 7 cm longi.... <i>S. chinensis</i> Briq., $\alpha$ . <i>parviflora</i> Kudo.   |
|   |   | Flores majores, ca. 1.1 cm longi.... <i>S. chinensis</i> Briq., $\beta$ . <i>megalantha</i> Kudo.  |

23. *Satureia sachalinensis* (Fr. Schm.) Kudo.



*Calamintha umbrosa* Benth., var. *sachalinensis* Fr. Schm. Fl. Sachal. (1868) p. 164; Herder, Pl. Radd. Monop. VIII. p. 45, et in Bull. de Boscou LXI. p. 163.

var. **japonica** Kudo. (Tab. II, fig. 23.).

*Calamintha umbrosa* Benth., var. *japonica* Fr. et Sav. Enum. Fl. Jap. I. (1875) p. 368.

*Melissa cretica* Thunb. Fl. Jap. (1784) p. 247, (non L.).

*Calamintha umbrosa* Miq. Prol. Fl. Jap. (1866-67) p. 38, (non Benth.).

*Clinopodium umbrosum* Matsum., var. *japonica* Matsum. Ind. Pl. Jap. II. 2. (1912) p. 538.

*Satureia umbrosa* Briq., var. *japonica* Matsum. et Kudo, in Schid. Imp. Univ. Tokyo.

NOM. JAP. *Miyama-tōbana*.

HAB. *Hokkaido*. Prov. Oshima: Gamushi (Y. Kudo! n. 3793, Aug. 1917); Shiribuchi (Miyabe et Tokubuchi! Julio 1890); in silvis Ichinowatari (Miyabe et Tokubuchi! Julio 1890); in monte Sasayama, prope Yesashi (Y. Tokubuchi! Aug. 1888); Hakodate (F. C. Greatrex! Sept. 1915 et Aug. 1916).—Prov. Shiribeshi: ins. Okushiri (K. Miyabe! Julio 1890); in monte Kamui, ins. Okushiri (Y. Kudo! n. 2381, Aug. 1916); inter Tsurikake et Garo, ins. Okushiri (Y. Kudo! n. 2265, Aug. 1916); Tsurikakekozan, ins. Okushiri (Y. Kudo! n. 2437, Aug. 1916); Kumaishi (Miyabe et Tokubuchi! Julio 1890); monte Iwaonupuri (M. Takenouchi! Aug. 1916).—Prov. Iburi: in silvis Tomakomai (Y. Kudo! n. 4827, Oct. 1919); ad pedem montis Makkarinupuri (Y. Kudo! n. 151, Aug. 1913); Makkarinupuri (K. Totsu! Aug. 1895); inter Date et Sobetsu (Y. Kudo! n. 4026, Aug. 1917); Osatsu (Y. Tokubuchi! Aug. 1893).—Prov. Hidaka: Saruru (Y. Tokubuchi! Aug. 1892); Samani (Y. Tokubuchi! Aug. 1892).—Prov. Ishikari: in silvis Nopporo (Y. Kudo! n. 1328 et 1329, Sept.

1915); Hassabu (M. Takenouchi! Sept. 1917); Sapporo (Class'80! Julio 1878; K. Miyabe! Aug. 1880; Juro Kawakami! 1890); in monte Teine (H. Yanagisawa! Sept. 1913); Ishiyama (Y. Tokubuchi! Aug. 1894); in monte Yubari (S. Nishida! Aug. 1913); ad pedem montis Taisetsu (H. Koidzumi! Julio 1911); Yubari-tanzan (Y. Tokubuchi! Aug. 1893); Utashinai (Y. Tokubuchi! Sept. 1892); Kamuikotan (K. Miyabe! Aug. 1891); in monte Mikami (S. Nishida! Aug. 1917).—Prov. Teshio: Masuke (S. Hori! Aug. 1887).—Prov. Kitami: Sarubutsu (T. Ishikawa! Oct. 1892); ad pedem montis Rishiri, ins. Rishiri (Y. Kudo! n. 2057, Julio 1916).

DISTRIB. *var.* Hokkaido, Honshu; *sp.* Sachalin.

Habitu convenit cum *Satureia sachalinensi*, sed differt corollis exsertis, calycibus minoribus.

In *Satureia umbrosa*, caules numerosi, diffusi, pubescentes vel villosi. Folia ovata basi rotundata. Calycis dentes superiores subulati. In nostra, caules erecti vel adscendentes, parcissime pubescentes vel glabri. Folia ovato-oblonga vel late ovata basi saepe subcuneata. Calycis dentes superiores acuti.

Ouid sit *Calamintha umbrosa* Benth., *var. shibetchensis* Lév'l. in Fedde Repert. IX. (1911) p. 322, ad silvam Shibetcha a Faurie collecta, ab defectum speciminis authenticici non dijudicandum. Ex descriptione certe *Satureia sachalinensi* Kudo valde affinis.

24. ***Satureia ussuriensis*** (Rgl. et Maack) Kudō. (Tab. II, fig. 24.).

*Calamintha ussuriensis* Rgl. et Maack. in Rgl. Tent. Fl. Ussuri. (1862) p. 118, t. IX. fig. 10–11.

NOM. JAP. *Hime-tōbana* (nov.).

HAB. *Hokkaido*. Prov. Iburi: Muroran, in silvis (Y. Kudo! n. 4023, Aug. 1917).

DISTRIB. Hokkaido et Ussuri.

25. **Satureia chinensis** Briq.\* Labiat. in Engl. u. Prantl, Nat. Pfl.-fam. IV. 3. a. (1897) p. 302; Diels, Fl. Centr. China, in Engl. Bot. Jahrb. XXIX. (1901) p. 559; Loesner, in Engl. Bot. Jahrb. XXXV. (1904) Beibiatt. Nr. 75, p. 63; Nakai, Fl. Korea. II. (1911) p. 148; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 299.

*Calamintha chinensis* Benth. in DC. Prodr. XII. (1848) p. 233; Maxim. Prim. Fl. Amur. (1859) p. 217 (var. *grandiflora* Maxim.); Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 639; Hance, in Ann. Soc. Nat. 5<sup>me</sup> série, V. p. 235; Franch. Pl. David. I. p. 236, et in Mém. Soc. Nat. Cherbourg. XXIV. p. 242; Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 283; Korsh. Pl. Amur. (1892) p. 377; Henry, List Pl. Formos. p. 72; Palib. Consp. Fl. Korea. II. (1900) p. 27; Matsum. et Hayata, Enum. Pl. Formos. (1906) p. 310; Kom. Fl. Mansh. III. (1907) p. 374; Dunn and Tutchet, Fl. Kwangt. and Hongk. (1912) p. 210.

*Clinopodium vulgare* Thunb. Fl. Jap. (1784) p. 247, (non L.).

*Calamintha Clinopodium* Benth., var. *chinensis* Miq. in Ann. Mus. Bot. Lugd. Bat. II. p. 236, et Prol. Fl. Jap. p. 39 (1866–67); Dunn, in Notes Roy. Bot. Gard. Edinbg. Vol. VI. Numb. XXVIII. (1915) p. 159.

*Calamintha Clinopodium* Benth., var. *urticifolia* Hance, in Ann. Sc. Nat. 5<sup>me</sup> série V. p. 236.

*Clinopodium chinense* O. K. Gen. Pl. II. (1891) p. 515; Makino, Bot. Mag. Tokyo, XX. (1906) p. 3; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 538.

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\* Huic speciei affinis est **Satureia macrantha** Kudo.=*Clinopodium chinense* O. K., var. *macranthum* Makino, Bot. Mag. Tokyo, XX. (1906) p. 3.=*Satureia chinensis* Briq., var. *macrantha* Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 299.

*α. parviflora* Kudo.\* (Tab. II, fig. 25, a—c).

Flores parvi. Corolla calycem subæquans vel eo demidio superans.

NOM. JAP. *Kurumabana*.

HAB. *Hokkaido*. Prov. Oshima: Tate-ishino, prope Fukuyama (Y. Kudo! n. 3796, Aug. 1917); Fukuyama (Miyabe et Tokubuchi! Julio 1890); Hakodateyama (Miyabe et Tokubuchi! Julio 1890); Kamiiso (F. C. Greatrex! Julio et Aug. 1916); Akanuma, prope Hakodate (F. C. Greatrex! Oct. 1915); Kikonai (Miyabe et Tokubuchi! Julio 1890); Goryokaku (Y. Tokubuchi! Julio 1888).—Prov. Shiribeshi: Suttu (Y. Tokubuchi! Julio 1888); Kudo (Miyabe et Tokubuchi! Julio 1890); in ins. Okushiri, inter Horonai et Aonai (Y. Kudo! n. 2520, Aug. 1916).—Prov. Iburi: in silvis Muroran (Y. Kudo! n. 317, Julio 1914 et n. 4202; Aug. 1917); Sobetsu, Date (Y. Kudo! n. 4025, Aug. 1917); in silvis Tomakomai (T. Yoshini! Aug. 1914); Yakumo (Y. Odagiri! Julio 1894); Yubutsu (K. Miyabe! Aug. 1884).—Prov. Hidaka: inter Horoman et Horoidzumi (Y. Kudo! n. 615, Sept. 1914); in monte Orokunne-nupuri (Y. Kudo! n. 619, Sept. 1914); Shoya (Y. Tokubuchi! Aug. 1892; Y. Kudo! n. 616, Aug. 1914); inter Motoura et Urakawa (Y. Kudo! n. 617, Aug. 1914); inter Mitsuishi et Motoura (Y. Kudo! n. 618, Aug. 1914); Samani-sando (K. Kondo! Aug. 1912); Horoman (Y. Tokubuchi! Aug. 1892); Erimosaki (Y. Tokubuchi! Aug. 1892); Saruru-sando (K. Miyabe! Aug. 1884).—Prov. Ishikari: in silvis Nopporo (Y. Kudo! n. 1327, Sept. 1915); Takinokuchi, Teine (M. Takenouchi! Julio 1916); Sapporo (Class'80! Sept. 1878; K. Miyabe! Julio 1880); in monte Teine (H. Yanagisawa! Sept. 1915; Kamunikotan

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\* Formæ duæ sunt: forma **pubescens**, foliis parce vel dense pubescentibus, et forma **lanata**, foliis caulibusque albo-lanatis; sed gradus pubescentiæ tam variabilis, ut varietates duas distinguere, nisi speciminum collectorum copia doceret, alteram in alteram paulatim transire.

(K. Miyabe! Aug. 1891); Kamikawa (H. Koizumi! 1911); Umon, Kamikawa (K. Miyabe! Aug. 1891); Kuriyama (J. Hanzawa! Oct. 1903); Poronai (Y. Tokubuchi! Aug. 1887).—Prov. Teshio: Wienbetsu (T. Ishikawa! Julio 1891); Tumbetpo, ad fl. Teshio (T. Ishikawa! Julio 1892).—Prov. Tokachi: Obihiro (T. Yanagimoto! Julio 1894); Hombetsu (S. Yenomoto! Aug. 1918).—Prov. Kushiro: in monte Meakan (T. Kawakami! Aug. 1897); Akan (I. Muto! Aug. 1917); Shakubetsu (M. Nakamura! Sept. 1888); Sempoji (K. Miyabe! Aug. 1884).—Prov. Nemuro: Nemuro (D. Hoshi! Aug. 1912).—Prov. Kitami: ins. Rebun (K. Miyabe! Aug. 1894).

*Chishima*. Ins. Etorofu: Nobori-sando, prope Shana (S. Fujimura! Aug. 1890).

DISTRIB. Hokkaido, Honshu, Kiushu, Liukiu, Formosa, Korea, China et Manchuria.

*β. megalantha* (Diels) Kudo. (Tab. II, fig. 25, d—f.).

*Calamintha chinensis* Benth., var. *megalantha* Diels, in Notes. Roy. Bot. Gard. Edinbg. XXV. p. 233.

*Calamintha Clinopodium* Benth., var. *megalantha* Dunn, Notes, Roy. Bot. Gard. Edinbg. XXVIII. p. 159.

NOM. JAP. *Oku-kurumabana* (nov.).

HAB. *Hokkaido*. Prov. Oshima: Shinmeizawa (Y. Kudo! n. 3797, Aug. 1916); in monte Sasayama (Y. Kudo! n. 3794, Aug. 1917); ad fl. Todo, prope Yesashi (Kudo! n. 3795, Aug. 1917); Kamiiso (F. C. Greatrex! Aug. 1916); Hakodate (F. C. Greatrex! Aug. 1916).—Prov. Iburi: Tomakomai (J. Hanzawa! Aug. 1899; Y. Kudo! Aug. 1914); Yubutsu (J. Hanzawa! Aug. 1899; Y. Kudo! Aug. 1914).—Prov. Tokachi: Uraboro (K. Hori! Aug. 1896).—Prov. Nemuro: Nemuro (T. Yagihashi! Aug. 1910).

DISTRIB. Hokkaido et China.



15. **Thymus** L.

26. **Thymus serpyllum** L. Spec. Pl. ed. 1. (1753) p. 590; Benth. in DC. Prodr. XII. (1848) p. 200 ( $\alpha$ . *vulgaris* et  $\beta$ . *montanus*); Ledeb. Fl. Ross. III. (1846–51) p. 245 (*varietates*); Trautv. et Mey. Fl. Ochot. p. 72 (var. *canescens* C. A. Mey); Rgl. et Til. Fl. Ajan (1859) p. 115 (var. *vulgaris* Benth.); Maxim. Prim. Fl. Amur. (1859) pp. 217, 475 (vars. *vulgaris* et *angustifolius* Ledeb.); Regel, Tent. Fl. Ussuri (1862) p. 116; Fr. Schm. Fl. Amg-Bur. (1868) p. 58; Debaux, Fl. Tchef. p. 108; Franch. Pl. David. p. 235 et in Mem. Soc. Nat. Cherbourg, XXIV. p. 242; Herder, Pl. Radd. Monop. VIII. p. 23 et in Bull. Mosc. LXI. p. 141 (*varietates*); Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 282; Korsh. Pl. Amur. (1892) p. 377; Kom. Fl. Mansh. III. (1907) p. 377; Nakai, Fl. Korea. II. (1911) p. 152; Dunn, Key Labiat. China, in Notes Roy. Bot. Gard. Edinbg. VI. Numb. XXVIII. (1915) p. 157.

var. **ibukiensis** Kudo. (Tab. II, fig. 26.).

*Thymus serpyllum* L.,  $\alpha$ . *vulgaris* Miq. Prol. Fl. Jap. (1866–67) p. 37; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 367; Yabe, Bot. Mag. Tokyo, XVII. (1903) p. 25; Matsum. Ind. Jap. II. 2. (1912) p. 552.

Caulis procumbens, lignosus, ramis et ramulis adscendentibus, subglabris vel parce albo-pilosis, puberulis. Folia petiolata, ovata, ovato-oblonga, ovato-elliptica, oblongo-elliptica, utraque facie glabra et dense punctata, margine nuda vel longe albo-ciliata. Calyx glaber vel parcissime puberulus vel parcissime pilosus, intus fauce villosus, 4–5 cm longus. Corolla sæpe calycem subduplo superans, 8 mm longa.

NOM. JAP. *Ibuki-jakōsō*, *Hyakurikō*.

HAB. *Hokkaido*. Prov. Oshima: inter Fukuyama et Shirakami



(Y. Kudo! n. 3800, Aug. 1917).—Prov. Shiribeshi: Togappu, Oemura (I. Yamamoto! Oct. 1914); in monte Kamui, ins. Oknshiri (Y. Kudo! n. 2382, Aug. 1916).—Prov. Iburi: Pankerup-kepushnai, prope Mukawa (T. Ishikawa! Julio 1917).—Prov. Hidaka: monte Orokunnanupuri (Y. Kudo! n. 626, Aug. 1914); Samani-sando (K. Miyabe! Aug. 1884, floribus rubescentibusque albis; S. Nozawa! 1890); Horomanbetsu (Y. Tokubuchi! Aug. 1892); Mt. Apoi (K. Kondo! Aug. 1912).—Prov. Ishikari: monte Yubari (Yanagisawa et Hamana! Aug. 1912).—Prov. Kitami: Shonai-sando (S. Nishida! Aug. 1917); ins. Rishiri (T. Kawakami! Aug. 1899; T. Yagihashi! Julio 1910); monte Rishiri, ins. Rishiri (W. Hirose! Aug. 1896); oppid. Oshidomari, ins. Rishiri (Y. Ito! Aug. 1896); inter Kafuka et Uennai (Y. Kudo! n. 1792, Julio 1916); ins. Rebun (K. Miyabe! Aug. 1894; S. Hori! Aug. 1888).

DISTRIB. *var.* Sachalin, Hokkaido, Honshu, *sp.* Korea, Manchuria, Amur, Sibiria, China, India septentrionalis, Africa borealis et Europa.

## 16. *Lycopus* L.

### CLAVIS SPECIERUM DICHOTOMA.

- |   |   |   |                                      |
|---|---|---|--------------------------------------|
| 1 | { | Nuculæ dentes calycinos superantes. Flores parvi, ca. 2 mm longi.   |                                      |
|   |   | Calycis dentes ovati, acuti .....   | <i>L. parviflorus</i> Maxim.         |
|   | { | Nuculæ dentibus calycinis breviores. Flores majores 3–4 mm longi.   |                                      |
|   |   | Calycis dentes subulati vel lanceolato-acuminati .....  | 2.                                   |
| 2 | { | Stamina fertilia corollæ tubo inclusa. Calycis dentes subulati.....   |                                      |
|   |   | .....   | <i>L. Maackianus</i> Kom.            |
| 3 | { | Stamina fertilia corollæ lobos subæquantia. Calycis dentes lanceolati....   | 3.                                   |
|   |   | Flores ca. 4.2 mm longi. Folia rigide coriacea, oblongo-lanceolata, apice acuminata, margine argute dentata ..... | <i>L. lucidus</i> Turcz.             |
|   |   | Flores ca. 3.1 mm longi. Folia membranacea, lanceolato-oblonga, oblongo-ovata, margine sinuato-dentata.....       | <i>L. japonicus</i> Matsum. et Kudo. |

27. **Lycopus parviflorus** Maxim. (Tab. II, fig. 27.) Prim. Fl. Amur. (1859) p. 216; Fr. Schm. Fl. Sachal. (1868) p. 264; Kom. Fl. Mansh. III. (1907) p. 382; Tokubuchi; in Miyabe's Festschrift, (1911) p. 278; Miyabe et Miyake, Fl. Saghal. (1915) p. 361.

*Lycopus virginicus* L., var. *parviflorus* Makino, in Bot. Mag. Tokyo, XI. (1897) p. (382) et *ibidem* XII. (1898) p. 119; Koidzumi, Pl. Sachal. Nakah. (1910) p. 105; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 543; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 300.

*Lycopus virginicus* Herder, Pl. Radd. VIII. p. 14, et Bull. de Moscou, LXI. 1. p. 132, (non L.).

NOM. JAP. *Yezo-shirone*, *Yezo-koshirone*.

HAB. *Hokkaido*. Prov. Oshima: Gamushi (Y. Kudo! n. 3787, Aug. 1916); Todohokke (K. Miyabe! Aug. 1890); Hakodate (F. C. Greatrex! Aug. 1916).—Prov. Shiribeshi: in monte Iwaonupuri (M. Takenouchi! Aug. 1916); ins. Okushiri (Miyabe et Tokubuchi! Julio 1890).—Prov. Iburi: in silvis Tomakomai (T. Yoshimi! Aug. 1914; Y. Kudo! n. 4826, Oct. 1919); ad pedem montis Makkarinupuri (K. Toyohira! Aug. 1916); Usu (K. Miyabe! Aug. 1890); Numanohata (J. Hanzawa! Aug. 1899).—Prov. Hidaka: Saruru (T. Tokubuchi! Aug. 1892).—Prov. Ishikari: Sapporo (Y. Tokubuchi! Junio et Sept. 1890; Y. Kudo! n. 1324, 1917); in silvis Nopporo (Y. Kudo! n. 1324, Sept. 1915; K. Tsutsuki! Aug. 1918, et Oct. 1919); Garugawa (M. Takenouchi! Sept. 1917); Hassabu (M. Takenouchi! Julio 1917); Soseigawa (Y. Tokubuchi! Aug. 1887); Sunagawa (K. Miyabe! Aug. 1891); Sorachibuto (K. Miyabe! Aug. 1891); Asahigawa (J. Hanzawa! Oct. 1903); in monte Mikami (S. Nishida! Aug. 1917).—Prov. Teshio: Pompira (Ninoue! Sept. 1905).—Prov. Kushiro: in monte Meakan (T. Kawakami! Aug. 1897); Atoëka (K. Miyabe! Julio 1894).—Prov.

Nemuro : Tomoshiri (D. Hoshi ! Aug. 1912) ; Nemuro (M. Nakamura ! Aug. 1884).—Prov. Kitami : Wakkanai, Koëtoi (H. Ishidoya ! Oct. 1916) ; Shari (K. Miyabe ! Aug. 1894) ; oppid. Oshonnai, ins. Rebun (Y. Kudo ! n. 1782, Julio 1916) ; oppid. Kafuka, ins. Rebun (Y. Kudo ! n. 1783, Julio 1916).

*Chishima*. Ins. Etorofu : Shana (T. Kawakami ! Aug. 1898).

DISTRIB. Sachalin, Hokkaido, Honshu, Amur, Ussuri et Kamtschatka.

28. **Lycopus Maackianus** Kom. Fl. Mansh. III. (1907) p. 381 ; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912). p. 300.

*Lycopus lucidus* Turcz., var. *Maackianus* Maxim. apud Herder, Pl. Radd. Monop. VIII. p. 13, et in Bull. Nat. Moscou, XLI. 1. p. 131 ; Korsh. Pl. Amur. (1892) p. 376.

*Lycopus sinuatus* Rgl. Tent., Fl. Ussuri (1862) p. 115.

*Lycopus lucidus* Turcz. form. *angustifolia*? Miq. Prol. Fl. Jap. (1866–67) p. 37.

*Lycopus angustus* Makino, Bot. Mag. Tokyo, XI. (1897) p. (382) et XII. (1898) p. 105 ; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 542.

lusus **ramosus** Kudo. (Tab. II, fig. 28.).

Caulis elatus, sæpe ultra bi-pedalis, valde ramosus.

NOM. JAP. *Hime-shirone*.

HAB. *Hokkaido*. Prov. Oshima : Esashi (Miyabe et Tokubuchi ! Aug. 1890) ; Junsainuma (Y. Tokubuchi ! Aug. 1888) ; Hakodate (F. C. Greatrex ! Aug. 1916).—Prov. Hidaka : inter Mitsuishi et Motoura (Y. Kudo ! n. 607, Aug. 1914) ; Shimokebo (Y. Tokubuchi ! Aug. 1892) ; Okoshi (Y. Tokubuchi ! Aug. 1892).—Prov. Ishikari : Sunakawa (Y. Kudō ! Aug. 1891) ; Gakuden, prope Nopporo (K. Tsutsuki ! Aug. 1918).

DISTRIB. Hokkaido, Honshu, Shikoku, Kiusiu, Manchuria, Ussuri et Amur.

lusus **simplex** Kudo.

Caulis pedalis usque ad bi-pedalis vulgo simplex.

NOM. JAP. *Hime-koshirone* (nov.).

HAB. *Hokkaido*. Prov. Oshima: Shikabe (K. Miyabe! Aug. 1890); Onuma (F. C. Greatrex! Aug. 1916); Yesashi (Miyabe et Tokubuchi! Aug. 1890).—Prov. Iburi: in silvis Tomakomai (Y. Kudo! n. 927, Junio 1915; Yoshimi! Aug. 1914); Nishitappu (Y. Kudo! n. 373, Julio 1914); Tomakomai (J. Hanzawa! Aug. 1899); Numanohata (J. Hanzawa! Aug. 1899); Yubutsu (J. Hanzawa! Aug. 1899).—Prov. Hidaka: in monte Orokunnanupuri (Y. Kudo! n. 609, Aug. 1914); Horomambetsu (Y. Tokubuchi! Aug. 1892).—Prov. Ishikari: Horomui (Y. Kudo! n. 2162, Julio 1916); Tsuiishikari (T. Mimatsu! Oct. 1910; T. Sakamura! Sept. 1912; Y. Kudo! n. 4358, Sept. 1918); Kariki (S. Yenomoto! Aug. 1918); Tobetsu (Y. Odagiri! Sept. 1893).—Prov. Tokachi: Hombetsu (S. Yenomoto! Aug. 1918).—Prov. Kushiro: Hamanaka (K. Miyabe! Aug. 1884).—Prov. Kitami: Abashiri (K. Miyabe! Aug. 1894).

DISTRIB. Endemica!

29. **Locopus lucidus** Turcz. (Tab. II, fig. 29.) Fl. Baic. Dah. II. p. 396; Benth. in DC. Prodr. XII. (1848) p. 178; Ledeb. Fl. Ross. III. (1846–51) p. 341; Maxim. Prim. Fl. Amur. (1859) pp. 217, 475; Regel, Fl. Ussuri (1862) p. 115; Fr. Schm. Fl. Sachal. (1868) p. 164; Herder, Pl. Radd. Monop. VIII. p. 12 et Bull. Mosc. LXI. 1. p. 130; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 367; Franch. Pl. David. I. p. 235; Korsh. Pl. Amur. (1892) p. 376; Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 282; Britt. and Brown, Ill. Fl. III. (1898) p. 118; Diels, Fl. Centr. China, in Engl. Bot. Jahrb. XXIX. (1901) p. 559; Loesn. in Engl. Bot. Jahrb. XXXIV. (1904) Beiblatt, Nr. 75, p. 64; Kom. Fl. Mansh. III. (1907) p. 379; Nakai, Fl. Korea. II. (1911) p. 151; Miyabe and Miyake, Fl. Saghal. (1914)

p. 362 ; Dunn, in Notes Roy. Bot. Gard. Edinbg. Vol. VI. Numb. XXVIII. (1915) p. 165 ; Hayata, General Index, Fl. Formos. (1916) p. 57.

*Lycopus lucidus* Turcz., var. *americanus* A. Gray, Proc. Am. Acad. VIII. (1870) p. 286, et Syn. Fl. North. Am. II. (1878) p. 353.

*Lycopus lucidus* Turcz.,  $\alpha$ . *genuinus* Herder, ll. cc. pp. 13, 131 ; Makino, Bot. Mag. Tokyo, XI. (1897) p. (381) et XII. (1898) p. 119 ; Hayata, Materials Fl. Formos. p. 277 ; Matsum. Ind. Fl. Jap. II. 2. (1912) p. 542 ; Matsum. et Kudo, Bot. Mag. Tokyo. XXVI. (1912) p. 300.

*Lycopus lucidus* Turcz., var. *typicus* Korsh. Pl. Amur. (1892) p. 376.

NOM. JAP. *Shirone*, *Oshirone*.

HAB. *Hokkaido*. Prov. Oshima : Hakodate (Y. Tokubuchi ! Julio 1888 ; F. C. Greatrex ! Aug. 1916) ; Kikonai (Miyabe et Tokubuchi ! Julio 1890) ; Kumaishi (Miyabe et Tokubuchi ! Julio 1890) ; Kamaya (Miyabe et Tokubuchi ! Julio 1890) ; Tomikawa-mura (Miyabe et Tokubuchi ! Julio 1890).—Prov. Shiribeshi : ins. Okushiri (Miyabe et Tokubuchi ! Julio 1890) ; Zenibako (Y. Tokubuchi ! Junio 1890).—Prov. Iburi : inter Wanishi et Date (Y. Kudo ! n. 372, Aug. 1917) ; Nishitappu (Y. Kudo ! n. 372, Julio 1914) ; in silvis Tomakomai (Y. Kudo ! n. 4825, Oct. 1919) ; Tomakomai (J. Hanzawa ! Aug. 1899) ; Abuta (K. Miyabe ! Aug. 1890) ; Yubutsu (J. Hanzawa ! Aug. 1899).—Prov. Hidaka : inter Mitsuishi et Motoura (Y. Kudo ! n. 608, Aug. 1914) ; Saruru (Y. Tokubuchi ! Aug. 1892) ; Okosli (Y. Tokubuchi ! Aug. 1892).—Prov. Ishikari : Sapporo (Class'80 ! Aug. 1878 ; Y. Tokubuchi ! Junio, Aug. et Sept. 1890) ; Kamikawa (K. Miyabe ! Aug. 1891) ; Sunakawa (K. Miyabe ! Aug. 1891) ; Shibumbetsu, Nopporo (K. Tsutsuki ! Aug. 1918).—Prov. Teshio : in silvis Teshio (Y. Kudo ! n. 4575, Julio 1919).—Prov. Kushiro :



Nusamai (M. Nakamura! Aug. 1886).—Prov. Nemuro: Nemuro (D. Hoshi! Aug. 1911).—Prov. Kitami: Shari (K. Miyabe! Aug. 1894); Soya (S. Hori! Aug. 1887); Oshonnai, ins. Rebun (Y. Kudo! n. 1781, Julio 1916).

DISTRIB. Sachalin, Hokkaido, Honshu, Formosa, Korea, China, Manchuria, Dahuria, Baicalia et America borealis.

Affinis ex habitu, *Lycopo europæo* L., a quo foliis crassioribus, margine argute dentatis, foliorum dentibus glandula terminatis, staminum steriliū rudimentis oblongo-clavatis facile distinguitur.

Ex characteribus vero protinus *Lycopo Maackiano* Kom., qui præsertim differt, caulibus multo elatioribus, crassioribus, foliis sæpe latioribusque firmioribus.

Species nostra affinis videtur, *Lycopo australi* Br. (Benth. in DC. Prodr. XII. p. 178), mihi tantum e descriptione nimis brevi cognito, sed a quo differe videtur, foliis latioribus.

In planta nostra, pubes foliorum valde variabilis. Folia utraque facie glabra, vel subtus ad nervos adpresse hirta vel supra parce hirtella et subtus glabra, tamen foliorum forma semper constans.

30. **Lycopus japonicus** Matsum. et Kudo, (Tab. II, fig. 30.) in Bot. Mag. Tokyo, XXVI. (1912) p. 300.

*Lycopus Maackianus* Makino, Bot. Mag. Tokyo XI. (1897) p. 382, et XII. (1898) p. 119, (non Kom.).

Caulis tenuis, erectus, 10–80 cm altus, simplex, interdum plusminus ramosus, glaber, ad nodos villosiusculus, striatus, basi stolones filiformes emittens. Folia oblongo-ovata vel lanceolato-oblonga, apice obtusa vel rotundata, basi ad petiolum attenuata, margine sinuato-dentata, supra obscure viridia, subtus pallidiora, utraque facie subglabra vel subtus ad nervos parcissime crispulo-pilosa, 2–9 cm longa, 1–2 cm lata, sursum sensim minora, petiolis inferioribus elongatis sursum abbreviatis. Verticillastri multiflori, bracteis



minutis. Flores ca. 3.1 mm longi. Calyx pubescens, dentibus lanceolatis, apice rigide acuminatis, quorum 4 subæqualibus, uno brevior. Corolla calyce brevior, intus longe pilosa, ca. 2.9 mm longa. Stamina fertilia corollæ lobos subæquantia; sterilia filiformia apice vix incrassata. Nuculæ glabræ, calyce multo breviores.

NOM. JAP. *Inu-shirone*.

HAB. *Hokkaido*. Prov. Oshima: Hakodate (Miyabe et Tokubuchi! Aug. 1890; F. C. Greatrex! Aug. 1916); Esashi (Miyabe et Tokubuchi! Aug. 1890); Shiriuchi (Miyabe et Tokubuchi! Julio 1890).—Prov. Shiribeshi: Maruyama, prope Shioya (Y. Kudo! n. 2724, Aug. 1916).—Prov. Iburi: Yubutsu (J. Hanzawa! Aug. 1899).—Prov. Ishikari: Kami-Teine (M. Takenouchi! Sept. 1917); Sapporo (Class'80! Aug. 1878; K. Miyabe! Julio 1880); Poronai (Y. Tokubuchi! Julio 1887).—Prov. Teshio: Wassamu (Y. Kudo! n. 4656, Julio 1919); Masuke (S. Hori! Aug. 1887).—Prov. Nemuro: Nemuro (D. Hoshi! Aug. 1911).—Prov. Kitami: ins. Rebun (S. Hori! Aug. 1887).

DISTRIB. *Hokkaido*, *Honshu* et *Kiushu*.

## 17. *Mentha* L.

31. *Mentha sachalinensis* (Briq.) Kudo. (Tab. II, fig. 31.).

*Mentha arvensis* L., subsp. *haplocalyx* Briq., var. *sachalinensis* Briq. in Engl. u. Prantl, Nat. Pfl.-fam. IV. 3. a. (1897) p. 319; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 300; Miyabe and Miyake, Fl. Saghal. (1916) p. 361.

*Mentha arvensis* Fr. Schm. Fl. Sachal. (1868) p. 164; Koidzumi, Pl. Sachal. Nakah. (1910) p. 105, (non L.).

*Mentha canadensis* Herder, Pl. Radd. VIII. p. 7 et in Bull. Mose. LXI. 1. p. 119, (non L., quoad Pl. Sachal.).

*Mentha canadensis* L., var. *sachalinensis* Kudo., MSS.

NOM. JAP. *Yezo-hakka*.

HAB. *Hokkaido*. Prov. Oshima: Shinmeizawa, Fukuyama (Y. Kudo! n. 3788, Aug. 1917); Onuma (Y. Tokubucki! Aug. 1888; F. C. Greatrex! Aug. 1916); Hakodate (F. C. Greatrex! Oct. 1915); Narukagawa (F. C. Greatrex! Oct. 1915).—Prov. Iburi: Osatsu (Y. Tokubuchi! Aug. 1893); Tomakomai (J. Hanzawa! Aug. 1899); Numanohata (J. Hanzawa! Aug. 1899); inter Yubutsu et Numanohata (J. Hanzawa! Aug. 1899); ad pedem montis Makkarinupuri (K. Toyohira! Aug. 1916).—Prov. Hidaka: inter Mitsuishi et Motoura (Y. Kudō! n. 610, 611, Aug. 1914).—Prov. Ishikari: Hassabu (M. Takenouchi! Julio 1917); Sapporo (Class'80! Aug. 1878).—Prov. Tokachi: Hombetsu (S. Yenomoto! Aug. 1918).—Prov. Kushiro: Shakubetsu (M. Nakamura! Sept. 1888); Kushiro (I. Muto! Aug. 1917).—Prov. Kitami: Abashiri (K. Miyabe! Aug. 1894); Wakkanai (H. Ishidoya! Oct. 1916); Oshonnai, ins. Rebun (Y. Kudo! n. 1786, Julio 1916).

*Chishima*. Ins. Kunashiri: ad lacum Biroku, prope Ruyabetsu (C. Yendo! Aug. 1894).—Ins. Etorofu: Naibo (T. Kawakami! Aug. 1898).

DISTRIB. Sachalin, insulae Kurilenses, Hokkaido.

18. **Mosla** L.

## CLAVIS SPECIERUM DICHOTOMA.

Caulis humilis, sæpe 15 cm altus. Folia parva, ovato-elliptica, margine serrulata. Bractea orbiculares. Nuculae obsolete reticulatae .. *M. japonica* Maxim.

Caulis elatus, sæpe ultra pedalis. Folia majora, late ovata vel ovata, margine grosseserrata. Bractea lineari-lanceolatae. Nuculae laxae reticulatae ..  
..... *M. grosseserrata* Maxim.

32. **Mosla japonica** Maxim. (Tab. II, fig. 32.) in Bull. Acad.

Pétersb. XX. (1865) p. 461, et Mém. Biol. IX. (1874) p. 437; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 371; Engler, Vers. Entwicklungsges. Pfl.-Welt. I. (1879) p. 20; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 544; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 301.

*Micromeria* ? *perforata* Miq. Ann. Bot. Lugd. Bat. II. p. 106, et Miq. Prol. Fl. Jap. p. 38 (1866-67).

*Orthodon japonicus* Benth. in Oliv. Journ. Linn. Soc. IX. p. 167.  
NOM. JAP. *Yamajiso*.

HAB. *Hokkaido*. Prov. Oshima: Hiura (Miyabe! Aug. 1890).—Prov. Hidaka: Saruru-sando (Y. Tokubuchi! Aug. 1892); Horoidzumi (Y. Tokubuchi! Aug. 1892).—Prov. Kushiro: Meakan (T. Kawakami! Aug. 1897); ad lacum Akan (I. Muto! Aug. 1917).

DISTRIB. *Hokkaido*, Honshu et Shikoku.

33. ***Mosla grosseserrata*** Maxim. (Tab. II, fig. 33.) in Bull. Acad. Petersb. XX. (1865) p. 458, et Mém. Biol. IX. (1878) p. 432; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 370; Engler, Vers. Entwicklungsgesch. Pfl.-Welt. I. (1879) p. 20; Forb. et Hemsl. Ind. Fl. Sin. II. (1889-1902) p. 280; Palib. Consp. Fl. Korea. II. (1900) p. 27; Kom. Fl. Mansh. III. (1907) p. 391; Nakai, Fl. Korea. II. (1911) p. 145; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 544; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 301.

NOM. JAP. *Mizo-kōju*.

HAB. *Hokkaido*. Prov. Oshima: Hongo, prope Hakodate (F. C. Greatrex! Aug. 1916); Hakodate (F. C. Greatrex! Aug. et Sept. 1916).—Prov. Iburi: Tomakomai (Y. Kudo! Aug. 1914); Nishitappu (J. Hanzawa! Aug. 1899); Numanohata (J. Hanzawa! Aug. 1899).—Prov. Ishikari: Tsuishikari (Y. Kudo! n. 4359. Sept. 1918).

DISTRIB. *Hokkaido*, Honshu, Shikoku, Kiushu, Korea, Manchuria et China.

19. *Elsholtzia* Willd.

34. *Elsholtzia Patrini* Gareke, (Tab. II, fig. 34.) in Fl. v. Hall. II. (1856) p. 213; O. Kuntze, Rev. Gen. Pl. II. (1891) p. 517; Britt. and Brown, Ill. Fl. III. (1898) p. 124; Palib. Consp. Fl. Korea. II. (1900) p. 26; Makino, Bot. Mag. Tokyo, XX. (1906) p. 3; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 539; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 301.

*Mentha Patrini* Lepechin, in Nov. Acta Acad. Petrop. I. (1783) p. 336, t. 8.

*Sideritis ciliata* Thunb. Fl. Jap. (1784) p. 245; Benth. in DC. Prodr. XII. (1848) p. 447.

*Elsholtzia cristata* Willd. in Rœm. et Ust. Mag. Bot. (1790) 5, t. 1, et Spec. Pl. III. (1800) p. 59; Benth. in Wall. Pl. As. Rar. I. p. 29, et Spec. Labiat. p. 164, et in DC. Prodr. XII. (1848) p. 163; Ledeb. Fl. Ross. III. (1846–1851) p. 335; Maxim. Prim. Fl. Amur. (1859) p. 214; Rgl. Tent. Fl. Ussuri (1862) p. 114; Bot. Mag. t. 2560; Miq. Ann. Mus. Bot. Lugd. Bat. II. p. 103 et Prol. Fl. Jap. (1866–67) p. 36; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 364; Franch. Pl. David. I. p. 334, et Mem. Soc. Sc. Nat. Cherbourg. XXIV. p. 242; Hook. f. Fl. Brit. Ind. IV. (1885) p. 645; Herder, Pl. Radd. Monop. VII. p. 13, et Bull. Soc. Mosc. LIX. (1884) p. 243; Korsh. Pl. Amur. p. 375; Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 277; Diels, Fl. Centr. China, in Engl. Bot. Jahrb. XXIX. (1901) p. 560; Kom. Fl. Mansh. III. (1907) p. 389; Hayata, Materials, Fl. Formos. (1911) p. 227; Nakai, Fl. Korea. II. (1911) p. 146; Takeda, Fl. Shikotan (1915) p. 482; Dunn, in Notes, Roy. Bot. Gard. Edinbg. Vol. VI. Numb. XXVIII. (1915) p. 151.

NOM. JAP. *Naginata-kōju*.

HAB. *Hokkaido*. Prov. Oshima : Hakodate (F. C. Greatrex ! Sept. 1916).—Prov. Iburi : in silvis Tomakomai (Y. Kudo ! n. 4824, Oct. 1919 ; T. Yoshimi ! Sept. 1914).—Prov. Ishikari : in silvis Nopporo (Y. Kudo ! n. 1323, Sept. 1915) ; Sapporo (Class'80 ! Sept. 1878 ; Y. Tokubuchi ! Aug. 1887) ; Shiroishi (J. Hanzawa ! Sept. 1908) ; Yamahana (J. Hanzawa ! Oct. 1903).—Prov. Kushiro : Nusamai (M. Nakamura ! Sept. 1886).—Prov. Kitami : Wakkanai (H. Ishidoya ! Oct. 1916).

*Chishima*. Ins. Shikotan (M. Arai ! Sept. 1910).

DISTRIB. Insulæ Kurilenses, Hokkaido, Honshu, Shikoku, Kiu-shu, Formosa, Korea, Manchuria, Amur, Ussuri, China, Sibiria, Himalaya, Tibet, Europa orientalis, in Americam borealem introducta.

## 20. *Comanthosphace* S. L. Moore.

35. *Comanthosphace stellipila* S. Moore, in Jour. Bot. (1877) p. 293 ; Briq. in Engl. u. Prantl, Nat. Pfl.-fam. IV. 3. a. p. 328 ; Makino, Bot. Mag. Tokyo, XVI. (1902) p. 216 ; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 539 ; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 301.

*Elsholtzia stellipila* Miq. in Ann. Mus. Bot. Lugd. Bat. II. p. 103 et Prol. Fl. Jap. p. 35 (1866-67) ; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 363.

*Pogostemon stellipila* Benth. et Hook. f. Gen. Pl. II. p. 1180.

β. *japonica* Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 301.

*Elsholtzia japonica* Miq. in Ann. Mus. Bot. Lugd. Bat. p. 103, et Prol. Fl. Jap. (1866-67) p. 37 ; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 364.

*Comanthosphace japonica* S. Moore, in Jour. Bot. (1877) p. 293 ;  
Hook. f. Bot. Mag. t. 7463 ; Briq. l. c. p. 328.

*Pogostemon japonica* Benth. et Hook. f. Gen. Pl. II. p. 1180.  
forma. **sublanceolata** Matsum. et Kudo, l. c. (Tab. II, fig. 35.).

*Elsholtzia sublanceolata* Miq. ll. cc. pp. 35, 103.

*Pogostemon sublanceolata* Benth. et Hook. l. c.

*Comanthosphace sublanceolata* S. Moore, l. c. p. ; Briq. l. c. p.  
NOM. JAP. *Mikaëris*ō.

HAB. *Hokkaido*. Prov. Ishikari: Makomanai, prope Sapporo  
(K. Miyabe! Sept. 1883).

DISTRIB. *Hokkaido*, *Honshu* et *Shikoku*.

## 21. **Plectranthus** L'Herit.

### CLAVIS SPECIERUM FORMÆQUE DICHOTOMA.

- |   |   |   |   |
|---|---|---|---|
| 1 | { | Flores purpurei .....   | <i>P. trichocarpus</i> Maxim.                             |
|   | { | Flores albi.....  | 2.  |
| 2 | { | Nuculæ apice pubescentes. Flores parvi, ca. 5 mm longi .....              |   |
|   | { | .....   | <i>P. glaucocalyx</i> Maxim.                              |
|   | { | Nuculæ glabræ. Flores majores, ca. 7-8 mm longi .....                     | 3.  |
| 3 | { | Folia ovata vel late ovata, margine grosseserrata, cum petiolis 3-5 cm    |   |
|   | { | longa.....  | <i>P. inflexus</i> Vahl.                                  |
|   | { | Folia rhombeo-ovata, argute subdenticulato-serrulata, cum petiolis 5-8 cm |   |
|   | { | longa.....  | <i>P. inflexus</i> Vahl., form. <i>macrophyllus</i> Kudo. |

36. **Plectranthus trichocarpus** Maxim. (Tab. II, fig. 36.) Mél.  
Biol. IX. (1876) p. 657 ; Engler, Vers. Entwicklungsgesch, Pfl.-Welt.  
I. (1879) p. 20 ; Fr. et Sav. Enum. Pl. Jap. II. (1879) p. 462 ;  
Matsum. Ind. Pl. Jap. II. 2. (1912) p. 547 ; Matsum. et Kudo, Bot.  
Mag. Tokyo, XXVI. (1912) p. 302.



*Plectranthus inconspicus* Maxim. Mél. Biol. IX. (1878) p. 428, (non Miq.).

NOM. JAP. *Kurobana-no-hikiokoshi*.

HAB. *Hokkaido*. Prov. Oshima : ad fl. Todo, prope Yesashi (Y. Kudo ! n. 3790, Aug. 1917) ; ad fl. Oyobe, prope Fukuyama (Y. Kudo ! n. 3791, Aug. 1917) ; Shimeizawa, prope Fukuyama (Y. Kudo ! n. 3792, Aug. 1917) ; Musanosawa, Menamura (C. Suzaki ! Sept. 1914) ; Kakkumitoge (Y. Tokubuchi ! Aug. 1888) ; Junsainuma (Takenobu et Mimasu ! Julio 1883) ; Fukuyama (Miyabe et Tokubuchi ! Julio 1890) ; Konuma (F. C. Greatrex ! Oct. 1916) ; Kamiiso (F. C. Greatrex ! Aug. 1916).

DISTRIB. *Hokkaido* et *Honshu*.

37. ***Plectranthus glaucocalyx*** Maxim. in Prim. Fl. Amur. (1859) pp. 212 et 475, et Mél. Biol. IX. p. 426 ; Rgl. Tent. Fl. Ussuri (1862) p. 114 ; Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 362 ; Franch. Pl. David. p. 233, et Mém. Soc. Sc. Nat. Cherbourg. XXIV. p. 241 ; Herder, Pl. Radd. Monop. VII. p. 12 et Bull. Mosc. LIX. p. 242 ; Forb. et Hemsl. Ind. Fl. Sin. II. (1889–1902) p. 271 ; Kom. Fl. Mansh. III. (1907) p. 393 ; Nakai, Fl. Korea. II. (1911) p. 140.

*Plectranthus glaucocalyx* Maxim., *α. typicus* Maxim. Mél. Biol. IX. (1874) p. 246 ; Korsh. Pl. Amur. (1892) p. 375 ; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 302.

NOM. JAP. *Kita-hikiokoshi* (nov.).

HAB. *Hokkaido*. Prov. Oshima : Hakodate (Maximowicz ; F. C. Greatrex ! Oct. 1916) ; Yunokawa, prope Hakodate (F. C. Greatrex ! Sept. 1915).

DISTRIB. *Hokkaido*, *Korea*, *Manchuria*, *China*, *Amur*, *Ussuri*, *Honshu* (var. *japonica* Maxim.), *Kiushu* (var. *japonica* Maxim.).

38. ***Plectranthus inflexus*** Vahl, ex Benth. Labiat. p. 711, et DC. Prodr. XII. (1848) p. 61 ; Miq. in Ann. Mus. Bot. Lugd. Bat.

II. p. 100 et Prol. Fl. Jap. p. 32 (1866-67); Maxim. Mél. Biol. IX. (1874) p. 425; Franch. in Mém. Soc. Sc. Nat. Cherbourg. XXIV. p. 241; Engl. Vers. Entwicksgesch. Pfl.-Welt. I. (1879) p. 20; Forb. et Hemsl. Ind. Fl. Sin. II. (1889-1902); p. 272; Loesner, in Engl. Bot. Jahrb. XXXIV. (1905) Beiblatt, Nr. 75. p. 64.

*Ocimum inflexum* Thunb. Fl. Jap. (1784) p. 249.

*Plectranthus dubius* Vahl, in Benth. Labiat. p. p. 711, et DC. Prodr. XII. (1848) p. 61; Maxim. Mél. Biol. IX. (1874) p. 429. Fr. et Sav. Enum. Pl. Jap. I. (1875) p. 361.

NOM. JAP. *Yamahakka*.

HAB. *Hokkaido*. Prov. Hidaka: Horoizumi (Y. Tokubuchi! Aug. 1892).

DISTRIB. *Hokkaido*, Honshu (f. *typicus* et f. *umbrosus*), Shikoku, Kiushu (f. *typicus* et f. *umbrosus*), Korea et China.

forma **macrophyllus** (Maxim.). (Tab. II, fig. 37.).

*Plectranthus inflexus* Vahl, γ. *macrophyllus* Maxim. Mél. Biol. IX. p. 657; Matsum. Ind. Pl. Jap. II. 2. (1912) p. 546; Matsum. et Kudo, Bot. Mag. Tokyo, XXVI. (1912) p. 302.

NOM. JAP. *Ohba-yamahakka*.

HAB. *Hokkaido*. Prov. Oshima: Tateishino, prope Fukuyama (Y. Kudo! n. 3789, Aug. 1917); Hakodate (Miyabe et Tokubuchi! Aug. 1890; F. C. Greatrex! Sept. 1915, et Aug. 1916); Otoshibe (T. Kawakami! Sept. 1896).—Prov. Iburi: Muroran (Y. Kudo! n. 4022, Aug. 1917); Wanishi (Y. Kudo! n. 4021, Aug. 1917); Rebungetoge (Y. Miyabe! Aug. 1890).—Prov. Hidaka: monte Orokunnenupuri (K. Kudo! n. 614, Aug. 1914); Shoya (Y. Kudo! n. 612, Aug. 1914); inter Mitsuishii et Motoura (Y. Kudo! n. 613, Aug. 1914); Samani-sando (K. Miyabe! Aug. 1884; Y. Tokubuchi! Aug. 1892; K. Kondo! Aug. 1912); in monte Apoi (K. Kondo! Aug. 1912).—Prov. Ishikari: Makomanai (K. Miyabe! Sept. 1883);

Teine (Y. Tokubuchi ! Aug. 1887) ; Sapporo (Class'80 ! Aug. 1878).  
—Prov. Kushiro : Shakubetsu (M. Nakamura ! Sept. 1888 et Aug. 1890).

DISTRIB. Hokkaido et Honshu.



## Index nominum et Synonymorum alphabeticus.

- Agastache.** . . . . 70  
*rugosa.* . . . . 70  
*v. hypoleuca.* . . . . 70  
*f. lanceolata.* . . . . 71
- Ajuga.** . . . . 57  
*bastarda.* . . . . 58  
*Chaneti.* . . . . 58  
*ciliata.* . . . . 58, 59  
*f. Chaneti.* . . . . 58  
*f. glabrescens.* . . . . 58  
*f. typica.* . . . . 58  
*v. glabrescens.* . . . . 58  
*decumbens.* . . . . 58  
*genevensis.* . . . . 59  
*orientalis.* . . . . 59  
*yezoensis.* . . . . 57, 58  
*f. elongata.* . . . . 58  
*f. typica.* . . . . 57
- Calamintha chinensis.** . . . 91  
*v. megalantha.* . . . 93  
*Clinopodium, v. chinensis.* 91  
*v. megalantha.* . . . 93  
*v. urticifolia.* . . . 91  
*umbrosa.* . . . . 89  
*v. japonica.* . . . . 89  
*v. sachalinensis.* . . . 89  
*v. shibetschensis.* . . . 90  
*ussuriensis.* . . . . 90
- Chelonopsis.** . . . . 78  
*moschatus.* . . . . 78
- Clinopodium chinense.** . . . 91  
*v. macrantha.* . . . . 91  
*umbrosum, v. japonica.* . 89  
*vulgare.* . . . . 91
- Comanthosphace.** . . . . 105  
*japonica.* . . . . 106  
*stellipila.* . . . . 105  
*v. japonica.* . . . . 105  
*f. sublancoolata.* . . . 106  
*sublancoolata.* . . . . 106
- Dracocephalum.** . . . . 74  
*argemense.* . . . . 75  
*japonicum.* . . . . 74  
*Ruytschianum.* . . . . 75, 76
- v. argemense.* . . . . 76  
*v. japonicum.* . . . . 75  
*v. speciosum.* . . . . 76  
*v. vulgare.* . . . . 75
- Elsholtzia.** . . . . 104  
*cristata.* . . . . 104  
*japonica.* . . . . 105  
*monostachys.* . . . . 70  
*Patrini.* . . . . 104  
*stellipila.* . . . . 105  
*sublancoolata.* . . . . 106
- Galeopsis.** . . . . 79  
*bifida.* . . . . 80  
*Tetradit.* . . . . 79  
*subsp. bifida, v. bifida.* 80  
*v. bifida.* . . . . 80  
*v. parvifolia.* . . . . 80
- Glechoma.** . . . . 73  
*grandis.* . . . . 74  
*hederacea.* . . . . 73  
*v. grandis.* . . . . 74
- Lamium.** . . . . 81  
*album.* . . . . 81, 82  
*v. barbatum.* . . . . 82  
*v. petiolatum.* . . . . 82  
*amplexicaule.* . . . . 81  
*barbatum.* . . . . 82  
*gorganicum.* . . . . 82  
*maculatum.* . . . . 82  
*petiolatum.* . . . . 82  
*purpureum.* . . . . 74
- Leonurus.** . . . . 83  
*japonicus.* . . . . 84  
*macranthus.* . . . . 83  
*sibiricus.* . . . . 84
- Lophanthus rugosus.** . . . 70  
*v. hypoleuca.* . . . . 70
- Lycopus.** . . . . 95  
*angustus.* . . . . 97  
*australis.* . . . . 100  
*europeus.* . . . . 100  
*japonicus.* . . . . 100  
*lucidus.* . . . . 98
- f. angustifolius.* . . . . 97  
*v. americanus.* . . . . 99  
*v. genuinus.* . . . . 99  
*v. Maackianus.* . . . . 97  
*v. typicus.* . . . . 99
- Maackianus.** . . . . 97, 100  
*l. ramosus.* . . . . 97  
*l. simplex.* . . . . 97  
*parviflorus.* . . . . 96  
*sinnatus.* . . . . 97  
*virginicus.* . . . . 96  
*v. parviflorus.* . . . . 96
- Melissa cretica.** . . . . 89
- Mentha.** . . . . 101  
*arvensis.* . . . . 101  
*subsp. haplocalyx, v.*  
*sachalinensis.* . . . . 101  
*canadensis.* . . . . 101  
*v. sachalinensis.* . . . 101  
*Patrini.* . . . . 104  
*sachalinensis.* . . . . 101
- Micromeria perforata.** . . . 103
- Mosla.** . . . . 102  
*grosseserrata.* . . . . 103  
*japonica.* . . . . 102
- Nepeta.** . . . . 72  
*Fauriei.* . . . . 73  
*Glechoma.* . . . . 73  
*v. grandiflora.* . . . . 74  
*v. grandis.* . . . . 74  
*macrantha.* . . . . 73  
*subsessilis.* . . . . 72  
*f. Fauriei.* . . . . 73  
*f. interrupta.* . . . . 73  
*f. pauciflora.* . . . . 73  
*v. yezoensis.* . . . . 72
- Ocimum inflexum.** . . . . 108  
*Orthodon japonicus.* . . . 103
- Plectranthus.** . . . . 106  
*dubius.* . . . . 108  
*glaucoalyx.* . . . . 107  
*v. typicus.* . . . . 107

- inconspicuus*. . . . . 107  
*inflexus*. . . . . 107  
    *f. macrophyllus*. . . . . 108  
    *v. macrophyllus*. . . . . 108  
*trichocarpus*. . . . . 106  
*Pogostemon japonica*. . . . . 106  
    *stellipila*. . . . . 105  
    *sublanceolata*. . . . . 106  
**Prunella**. . . . . 76  
    *japonica*. . . . . 77  
    *vulgaris*. . . . . 76  
    *v. japonica*. . . . . 77  
    *v. vulgaris*. . . . . 77  
    *v. yezoensis*. . . . . 77  
**Satureia**. . . . . 88  
    *chinensis*. . . . . 91  
    *f. lanata*. . . . . 92  
    *f. pubescens*. . . . . 92  
    *v. macrantha*. . . . . 91  
    *v. megalantha*. . . . . 93  
    *v. parviflora*. . . . . 92  
    *macrantha*. . . . . 91  
    *sachalinensis*. . . . . 88  
    *v. japonica*. . . . . 89  
    *umbrosa, v. japonica*. . . . . 89  
    *ussuriensis*. . . . . 90  
**Scutellaria**. . . . . 63  
    *dentata*. . . . . 64  
    *dependens*. . . . . 65  
    *galericulata*. . . . . 67, 66  
    *f. hirta*. . . . . 68  
    *f. pubescens*. . . . . 68  
    *v. angustifolia*. . . . . 66  
    *v. puberula*. . . . . 66  
    *v. pubescens*. . . . . 68  
    *v. pubescens*. . . . . 66  
    *v. scordifolia*. . . . . 68  
    *indica, v. ussuriensis*. . . . . 63  
    *japonica*. . . . . 63  
    *v. ussuriensis*. . . . . 63  
    *minor*. . . . . 65  
    *nipponica*. . . . . 63, 65  
    *Oldhami*. . . . . 65  
    *Schmidtii*. . . . . 67  
    *scordifolia*. . . . . 68, 70  
    *f. puberula*. . . . . 66  
    *v. hirta*. . . . . 67  
    *v. puberula*. . . . . 66  
    *v. pubescens*. . . . . 68  
    *transitru*. . . . . 63  
    *ussuriensis*. . . . . 63  
    *yezoensis*. . . . . 66  
*Siderites ciliata*. . . . . 104  
**Stachys**. . . . . 85  
    *aspera, v. baicalensis*. . . . . 86  
    *v. chinensis*. . . . . 86  
    *v. japonica*. . . . . 85  
    *baicalensis*. . . . . 85, 88  
    *v. glabra*. . . . . 85  
    *v. japonica*. . . . . 85, 86  
    *chinensis*. . . . . 88  
    *japonica*. . . . . 85  
    *f. glabra*. . . . . 85  
    *f. intermedia*. . . . . 86  
    *f. villosa*. . . . . 86  
    *palustris, v. hispida*. . . . . 86  
**Thymus**. . . . . 94  
    *serpyllum*. . . . . 94  
    *v. ibukiensis*. . . . . 94  
    *v. vulgaris*. . . . . 94  
**Teucrium**. . . . . 59  
    *japenicum*. . . . . 61, 62  
    *f. hispidovillosum*. . . . . 61  
    *Miquelianum*. . . . . 62  
    *nepetoides*. . . . . 61  
    *nipponicum*. . . . . 60  
    *stoloniferum*. . . . . 62, 63  
    *v. Miquelianum*. . . . . 62  
    *teinense*. . . . . 60  
    *veronicoides*. . . . . 60  
    *virginicum*. . . . . 61



## Index nominum japonicorum alphabeticus.

<i>Chishima-odorikosō</i> . . . . .	89	<i>Kantorisō</i> . . . . .	74	<i>Odorikosō</i> . . . . .	82
<i>Chōrōgi-tamashi</i> . . . . .	86	<i>Kenashi-inugoma</i> . . . . .	86	<i>Ohba-yamahakka</i> . . . . .	108
<i>Huma-namikisō</i> . . . . .	68	<i>Kisewata</i> . . . . .	84	<i>Oku-kurumabana</i> . . . . .	93
<i>Hime-koshirone</i> . . . . .	98	<i>Kita-hikiokoshi</i> . . . . .	107	<i>Okuyama-misogawasō</i> . . . . .	73
<i>Hime-namiki</i> . . . . .	65	<i>Kita-kawamidori</i> . . . . .	71	<i>O-shirone</i> . . . . .	99
<i>Hime-shirone</i> . . . . .	97	<i>Kiumonsō</i> . . . . .	57	<i>Shirage-inugoma</i> . . . . .	87
<i>Hime-tōbana</i> . . . . .	90	<i>Kurobana-no-hikiokoshi</i> . . . . .	107	<i>Shirone</i> . . . . .	99
<i>Hosaba-kitakawamidori</i> . . . . .	72	<i>Mhajiki</i> . . . . .	85	<i>Teine-nigukusa</i> . . . . .	61
<i>Hotokezoza</i> . . . . .	81	<i>Mikaerisō</i> . . . . .	106	<i>Tsuru-nigakusa</i> . . . . .	62
<i>Iyakurikō</i> . . . . .	94	<i>Misogawasō</i> . . . . .	72	<i>Yamahakka</i> . . . . .	108
<i>Ibukijakōsō</i> . . . . .	94	<i>Miyama-tōbana</i> . . . . .	89	<i>Yamajiso</i> . . . . .	103
<i>Inugoma</i> . . . . .	86	<i>Miyama-utsubogusa</i> . . . . .	77	<i>Yezo-hakka</i> . . . . .	101
<i>Inu-shirone</i> . . . . .	101	<i>Mizo-kōju</i> . . . . .	103	<i>Yezo-koshirone</i> . . . . .	96
<i>Itachi-jiso</i> . . . . .	80	<i>Musha-rindō</i> . . . . .	75	<i>Yezo-namiki</i> . . . . .	67
<i>Jakōsō</i> . . . . .	78	<i>Nagaha-nishikiōromo</i> . . . . .	58	<i>Yezo-nigakusa</i> . . . . .	60
<i>Kai-jindō</i> . . . . .	59	<i>Naginata-kōju</i> . . . . .	104	<i>Yezo-shirone</i> . . . . .	96
<i>Kakidōshi</i> . . . . .	74	<i>Nigukusa</i> . . . . .	61	<i>Yezo-tatsunamisō</i> . . . . .	64
		<i>Nishikiōromo</i> . . . . .	57	<i>Yezo-utsubogusa</i> . . . . .	77



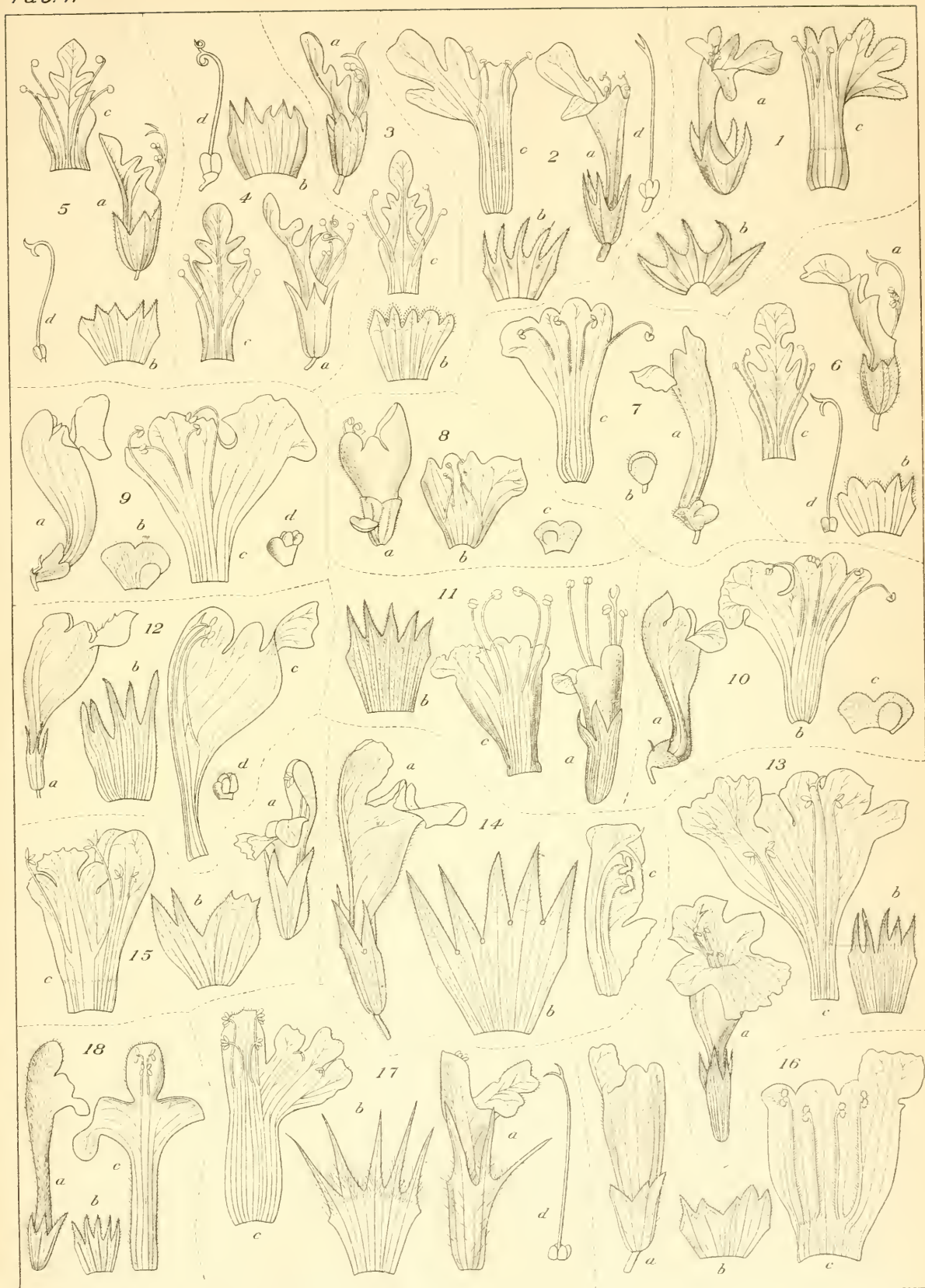
## Explicatio tabulæ I.

1. *Ajuga yezensis* Maxim. forma *typica* Kudo. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ .
2. *Ajuga ciliata* Bunge, forma *Chaneti* Kudo. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ . d. Stylus cum ovario,  $\times 3$ .
3. *Teucrium veronicoides* Maxim. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ .
4. *Teucrium toinense* Kudo. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ . d. Stylus cum ovario,  $\times 3$ .
5. *Teucrium japonicum* Willd. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ .
6. *Teucrium Miquelianum* Kudo. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ . d. Stylus cum ovario,  $\times 3$ .
7. *Scutellaria ussuriensis* Kudo. a. Flos,  $\times 2$ . b. Calyx,  $\times 2$ . c. Corolla fissa,  $\times 2$ .
8. *Scutellaris dependens* Maxim. a. Flos,  $\times 4$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ .
9. *Scutellaria yezensis* Kudo. a. Flos,  $\times 1.5$ . b. Calyx fissus,  $\times 2$ . c. Corolla fissa,  $\times 1.5$ .
10. *Scutellaria Schmidtii* Kudo. a. Flos,  $\times 1.5$ . b. Calyx fissus,  $\times 2$ . c. Corolla fissa,  $\times 1.5$ .
11. *Agastache rugosa* O. K. var. *hypoleuca* Kudo. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ .
12. *Nepeta subscissilis* Maxim. a. Flos,  $\times 1.5$ . b. Calyx fissus,  $\times 2$ . c. Corollæ sectio verticalis,  $\times 2$ .
13. *Glechoma hederacea* L. var. *grandis* Kudo. a. Flos,  $\times 2$ . b. Calyx fissus,  $\times 2$ . c. Corolla fissa,  $\times 2$ .
14. *Dracocephalum japonicum* Kudo. a. Flos,  $\times 1.5$ . b. Calyx fissus,  $\times 2$ . c. Galeæ sectio verticalis,  $\times 5$ .
15. *Prunella vulgaris* L. var. *japonica* Kudo. a. Flos,  $\times 2$ . b. Calyx fissus,  $\times 2$ . c. Corolla fissa,  $\times 2$ .
16. *Chelonopsis moschata* Miq. a. Flos,  $\times 1$ . b. Calyx fissus,  $\times 1$ . c. Corolla fissa,  $\times 1$ .
17. *Galeopsis Tetralit* L. var. *bifida* Syme. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissus,  $\times 3$ . d. Stylus cum ovario,  $\times 3$ .
18. *Lamium amplexicaule* L. a. Flos,  $\times 2$ . b. Calyx fissus,  $\times 2$ . c. Corolla fissa,  $\times 2$ .

## Explicatio tabulæ II.

19. *Lamium album* L. var. *barbatum* Fr. et Sav. a. Flos,  $\times 1$ . b. Calyx fissus,  $\times 1$ . c. Corolla fissa, 1.
20. *Leonurus macranthus* Maxim. a. Flos,  $\times 1.5$ . b. Calyx fissus,  $\times 1.5$ . c. Corolla fissa,  $\times 1.5$ .
21. *Leonurus sibiricus* L. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ .
22. *Stachys japonica* Miq. form. *villosa* Kudo. a. Flos,  $\times 2$ . b. Calyx fissus,  $\times 2$ . c. Corollæ sectio verticilis,  $\times 2$ .
23. *Satureia sachalinensis* Kudo, var. *japonica* Kudo. a. Flos,  $\times 4$ . b. Calyx fissus,  $\times 4$ . c. Corolla fissa,  $\times 4$ .
24. *Satureia ussuriensis* Kudo. a. Flos,  $\times 4$ . b. Calyx fissus,  $\times 4$ . c. Corolla fissa,  $\times 4$ .
25. *Satureia chinensis* Briq.
  - $\alpha$ . *parviflora* Kudo. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ .
  - $\beta$ . *megalantha* Kudo. d. Flos,  $\times 3$ . e. Calyx fissus,  $\times 3$ . f. Corolla fissa,  $\times 3$ .
26. *Thymus serpyllum* L. var. *ibukiensis* Kudo. a. Flos,  $\times 3$ . b. Calyx fissus,  $\times 3$ . c. Corolla fissa,  $\times 3$ .
27. *Lycopus parviflorus* Maxim. a. Flos,  $\times 10$ . b. Calyx fissus,  $\times 10$ . c. Corolla fissa,  $\times 10$ .
28. *Lycopus Maackianus* Kom. insus *ramosus* Kudo. a. Flos,  $\times 5$ . b. Calyx fissus,  $\times 5$ . c. Stylus cum ovario,  $\times 5$ .
29. *Lycopus lucidus* Turcz. a. Flos,  $\times 5$ . b. Calyx fissus,  $\times 5$ . c. Corolla fissa,  $\times 5$ .
30. *Lycopus japonicus* Matsum. et Kudo. a. Flos,  $\times 5$ . b. Calyx fissus,  $\times 5$ . c. Corolla fissa,  $\times 5$ .
31. *Mentha sachalinensis* Kudo. a. Flos,  $\times 4$ . b. Calyx fissus,  $\times 4$ . c. Corolla fissa,  $\times 4$ .
32. *Mosla japonica* Maxim. a. Flos,  $\times 5$ . b. Calyx fissus,  $\times 5$ . c. Corolla fissa,  $\times 5$ .
33. *Mosla grosseserrata* Maxim. a. Flos,  $\times 5$ . b. Calyx fissus,  $\times 5$ . c. Corolla fissa,  $\times 5$ .
34. *Elsholtzia Patrini* Gareke. a. Flos,  $\times 5$ . b. Calyx fissus,  $\times 5$ . c. Corolla fissa,  $\times 5$ .
35. *Comanthosphace stillipila* S. Moore, var. *japonica* Matsum. et Kudo, form. *lanceolata* Matsum. et Kudo. a. Flos,  $\times 2$ . b. Calyx fissus,  $\times 2$ . c. Corolla fissa,  $\times 2$ .
36. *Plectranthus trichocarpus* Maxim. a. Flos,  $\times 5$ . b. Calyx fissus,  $\times 5$ . c. Corollæ tubus,  $\times 5$ . d. Corolla fissa,  $\times 5$ . e. Ovarium,  $\times 7$ .
37. *Plectranthus inplexus* Vahl. forma *macrophyllus* (Maxim.) a. Flos,  $\times 4$ . b. Calyx fissus,  $\times 4$ . c. Corollæ tubus,  $\times 4$ . d. Corolla fissa,  $\times 4$ . e. Ovarium,  $\times 7$ .

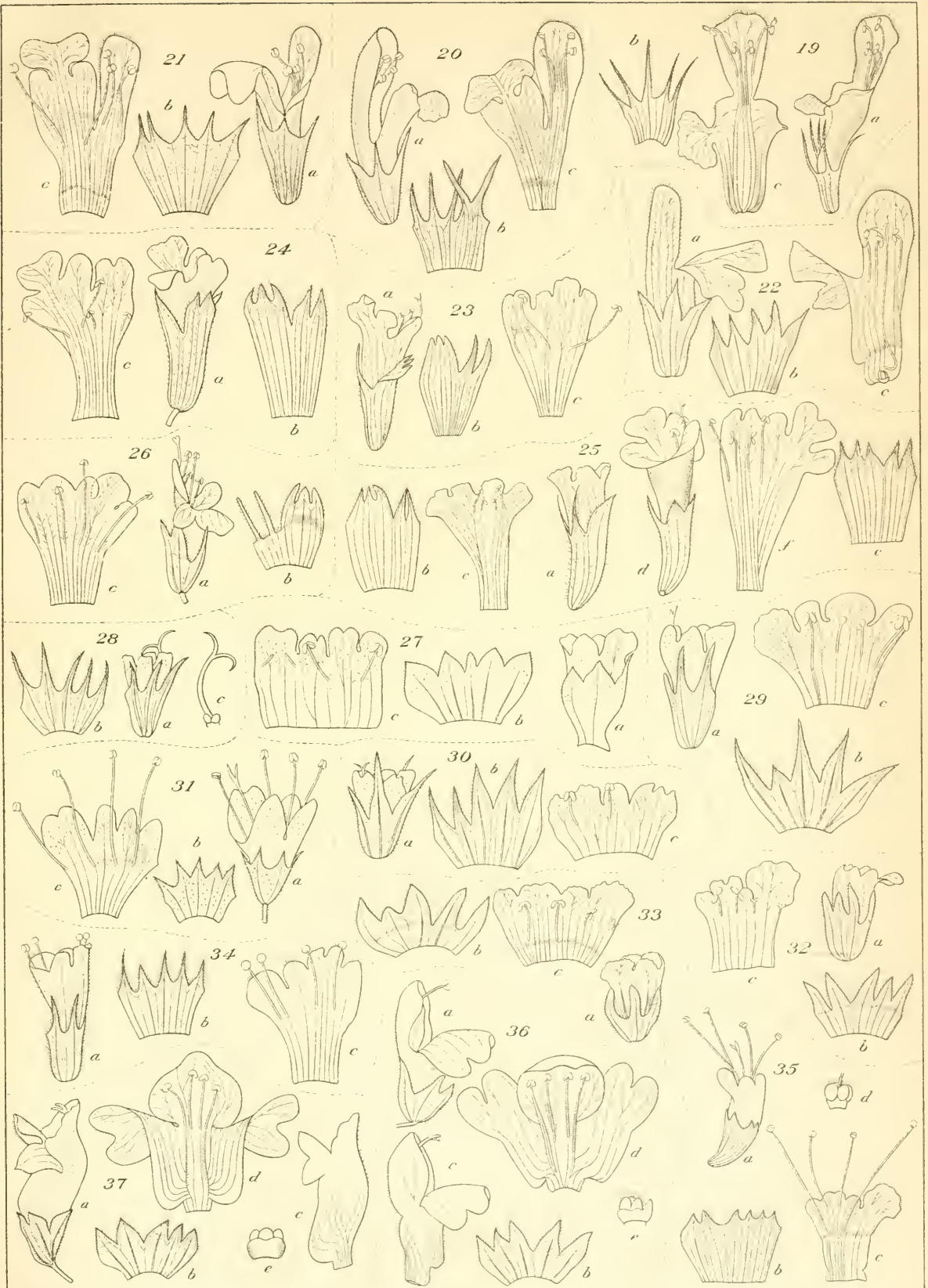
Tab. I.







Tab. II.









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